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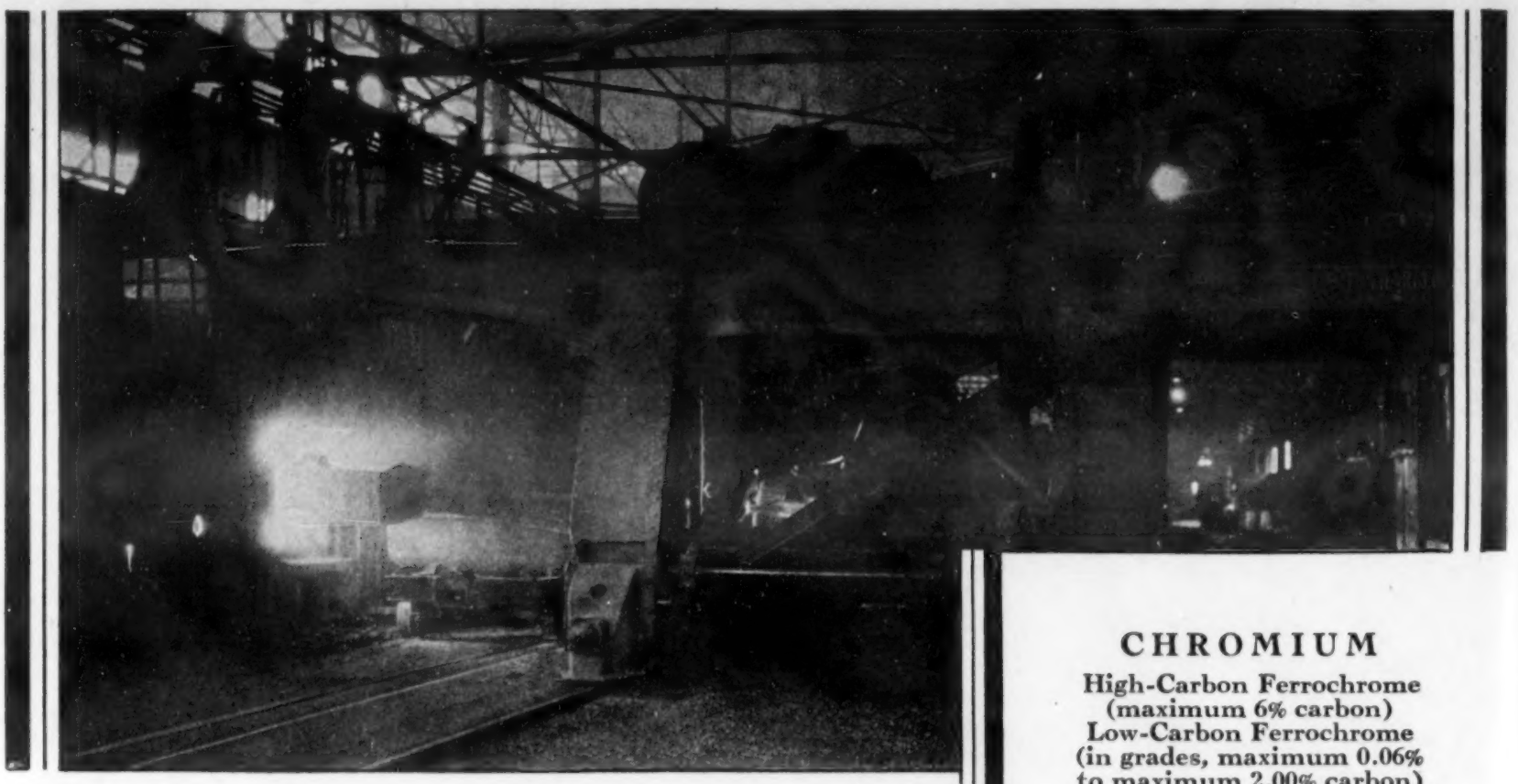

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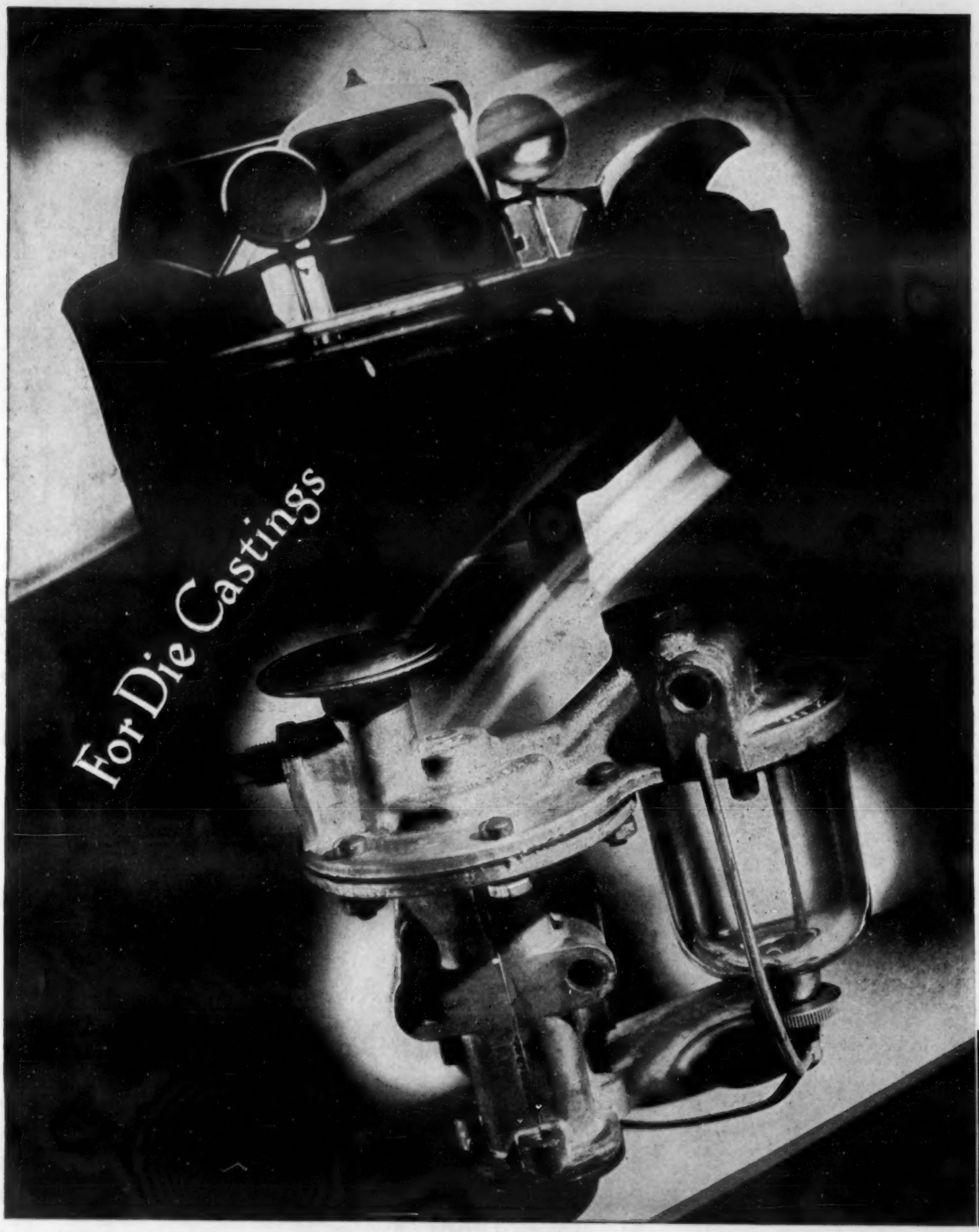
HORSE HEAD *UNIFORM QUALITY* ZINC



Fuel Pump die cast from an alloy of Horse Head—*uniform quality*—Zinc.

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Editorial Comment

Quality Factors

We used to know an engineer who was strong on getting everything down into what he called "tabbylated form." It is very nice to deal with quantitative figures which can be jotted down and added up to show by the logic of mathematics that there is one answer and one only. This urge is commendable, but there are many metallurgical factors that won't "tabbylate."

An interesting effort toward tabulation was made by Stoughton and Harvey[1] in their study of quality factors that have been suggested for appraisal of the value of different alloy steels in different conditions of heat-treatment. These took in only the ordinary tensile test values and, in cases where the data could be found, the impact values. Some efforts along this line seem to have been prompted by a desire to make the figures come out in favor of some special type of steel, but Stoughton and Harvey took the matter up without bias.

The spirited discussion on the paper at the A. S. T. M. Meeting indicated how much interest there would be in a true, all-inclusive "quality factor," and there will be further discussion of the subject here and abroad, brought up by this interesting paper.

Personally, we can't get very enthusiastic as to the possibility for success in the quest for a quality factor. It is an axiom of mathematics that you can't solve a problem involving N + 17, more or less, variables, with only N known factors. And there are certainly at least 17 if not 57 varieties of variables involved in the choice of a steel, that cannot as yet be put into quantitative figures. Moreover, depending on the use in hand, the weight to be given each variable will vary.

And in general, it seems to us that what we need is not the grouping of properties into one mathematical figure, but even more separation of the properties determined into their own constituent factors. For most static uses of steel, a set of stress-strain diagrams showing the area beneath the curve, clear up to the point of fracture, would be as illuminating as anything we could get. Sometimes figures for ductility of longitudinal and transverse specimens would be the most important sign posts. Again, data on endurance limit plus impact strength would be essential and sufficient. Formability, machinability or weldability might be the important thing. But any such methods or the use of the best imaginable "quality factor" based on the final properties of any given heat of steel wouldn't tell whether the composition of that heat was the one we wanted to specify. The difficulties of steel making, the ease of deoxidation and degasification, the freedom from non-metallic inclusions, and the uniformity of results from heat to heat, would all have to be considered.

No one has a more difficult task in the choice of a steel for a given use than has the maker of aircraft engines. The comments of Moore[2] of the Wright Aeronautical Corp., while not made as a discussion of quality factors, are certainly germaine. He says, "The selection of the proper steel to be used in various parts of an aircraft engine involves more than the mere writing of an S. A. E. number on the drawing. Behind the selection of a steel for a particular purpose there are a number of considerations to be taken into account. These not only relate to the performance of the steel but also to the methods of preparation which are necessary to put it into the proper condition to perform the functions demanded of it. The performance of steels is generally based on such properties as elastic limit, strength, hardness, ductility, fatigue, wearing quality, etc. However, these properties are only a few of those that contribute to the successful application of metals. Due consideration must also be given to such factors as uniformity, depth of hardening, tendency to warp, hardening range, forgeability, machinability, etc. All of these properties are inherent in the alloy and contribute to its success or failure in performing the functions for which it is intended."

As long as there is no accepted standard for an impact test, so that all kinds of notches are used, and till quantitative methods for evaluation of machinability, wear resistance and various other important properties are available, what chance have we of setting up any formula, however many factors it may include, that will rate steel A as 87 and steel B as 86, so that, at equal cost, we are sure we had best choose steel A?

These quality factors remind us of the "efficiency ratings" used to evaluate government employees. A whole lot of attributes are listed and you put a check mark at a phrase, such as "moderately coöperative," "highest possible degree of coöperativeness," etc., that you think most closely describes the employee being rated.

The various attributes are variously rated for different grades of positions, and a slide rule computation brings the result that one employee has an efficiency rating of 83.62% and another of 83.59%. The system has certain uses, but when you have a new responsibility to give to some one, you don't pull out the efficiency rating sheets to tell to whom it should be given, for the answer isn't there.

Quality factors have their uses, too, but we do not expect, in our life-time, to see one that will relieve the metallurgist of the responsibility for having an intimate knowledge of the attributes of the steel needed for a given use and for making his selection on the basis of the suitability of the steel for the job in hand, without much regard to a blanket, so-called, "quality factor."

[1] Stoughton, B. and Harvey, W. E. The Relative Merits of Some Different Alloy Steels With Respect to Certain Mechanical Properties. *Preprint* for June, 1930, Meeting, *American Society for Testing Materials*.

[2] Moore, R. R. Materials of Construction in Aircraft Engines. *Preprint* No. 33, June 1930 Meeting, *American Society for Testing Materials*, pages 46–56.

Interesting Uses of Barium and Beryllium

In the October issue of the Bell Laboratories Record, it is stated[1] that a quarter of a million platinum alloy filaments are used in vacuum tubes on the circuits of the Bell System. These are coated with barium oxide, and by electrolysis metallic barium is produced, a monatomic film of which reduces the energy required for heating to produce the necessary electron emission from 35 watts to 2.2.

The amount of metallic barium per tube is so small that the active metal in all the quarter of a million tubes is less than a twentieth of a gram. This saves a horsepower hour per tube per day or 90 million horsepower hours per year, if the tubes are kept constantly heated, and the saved energy is storage battery energy at that!

In the same issue, is a description[2] of one of the very few truly commercial uses of metallic beryllium, which because it stays put better than other materials, and does not blacken the lamp and cut down the intensity, is used as a facing on the cathodes of neon lamps, for monochromatic television.

In the preparation of the cathodes, small pieces of beryllium are welded to a tungsten heater which is, together with the cathode to be coated, put into a vacuum chamber. On heating in a high vacuum, the beryllium melts, and slowly vaporizes, the vapor condensing on the cathode, which is later mounted in the neon lamp.

[1] J. A. Becker. The Role of Barium in Vacuum Tubes. Vol. 9, Oct. 1930, pages 54–58.

[2] H. W. Weinhart. Glow Discharge Lamps for Television Systems. Vol. 9, Oct. 1930, pages 80–84

Cupola Melting of Bronze

By E. R. Darby*

Battery of Cupola Type Furnaces at Federal Mogul Corporation. For Another View See Front Cover.

Although the cupola or shaft type furnace has for years found general use in the smelting of non-ferrous ores and various secondary materials, its successful application to the melting of bronze for casting purposes is the result of very recent developments. A number of attempts have been made in the past to produce such castings from the usual type iron foundry furnace, but these attempts have in general been unsuccessful because of the character of available fuel and the design of furnace. It was in most instances found very difficult to maintain proper temperature and quality of metal, and as sulphur and other impurities were absorbed, the castings poured were frequently unsound and not fit for use.

With the recent development of pitch coke by the Barrett Co. an exceptionally high grade fuel was made available, which contains practically no ash, very little sulphur and better than 99% fixed carbon. Although the cost of this coke was considerably greater than the usual foundry variety, its high fuel value and remarkable purity were sufficient to throw the balance in its favor. Accordingly a furnace was designed for the express purpose of using this fuel in the melting of bronze and similar alloys, and after thorough and careful trial has now been adopted by a number of large firms making bronze castings.

The furnace with which the author has had experience has a melting capacity of about 2500 lbs./hr. This capacity depends somewhat upon the physical nature of the charge being melted. Very finely divided material such as turnings does not melt as rapidly as material consisting of larger particles such as sprues and cut-up runners. Ingot metal of the usual size, although melting more rapidly than turnings, will not melt quite as readily as the medium size material. However, with the usual charge composed of sprues, runners, turnings and some larger material, the capacity of the furnace should be close to the average figure as mentioned.

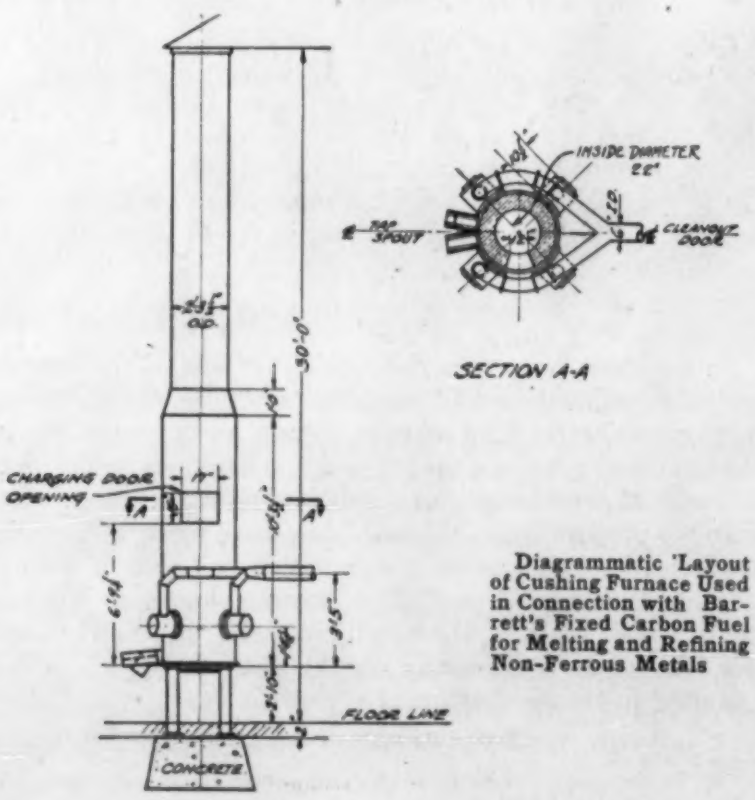
By referring to the general plan of the cupola it will be noticed that the inside diameter is 22 in. and the length of the shaft, from the bed plate to the charging door, is 6 ft. 9 in. The openings of the four tuyères are approximately 6 in.^{2} in area with their centers 18 in. above the bed plate. Deducting from this 3 in. for the thickness of bottom brick or lining, and the $1^1/_2$ in. from the center to the bottom of the tuyère opening, the crucible dimensions become $13^1/_2$ + 22 in. As in operation this space is largely filled with unburned coke, slightly over 500 lbs. of melted metal is all that it will safely accommodate.

The shell of the furnace, slightly over 10 ft. in length, is 3 ft. in diameter and is lined with the usual character of cupola block excepting the first 3 ft. above the bed plate. This section comprising the crucible and melting zone is lined with $4^1/_2$ in. of silicon carbide brick, backed with 2 in. of insulation. Because of the extreme temperature at and immediately above the tuyères, a lining of silicon carbide material or something of equal refractory properties is necessary. Monolithic linings for this section have been tried in several instances with considerable success, and they have the possible advantage of absence of joints and ease of application.

The bottom door which swings down and backward on a hinge may be permanently lined with firebrick, or after being supported in the closed position may be covered with a layer of loose brick and sand. The latter appears to be the better practice as very frequently a permanent lining is broken in dropping the bottom after a day's melting. The stack shell which is 27 in. in diameter is lined with $2^1/_2$ in. of ordinary fire brick. This makes the inside diameter 22 in. or exactly the same as the shaft, giving a clear passage for gases without restriction or obstruction of any kind.

The breast of the furnace is arranged for two tap holes made of a special block which may be removed and replaced during operation if necessary. The extra tap hole was thought advisable originally because of the possibility of freeze-up due to slag. However, by always keeping a small amount of metal on the bottom or rather by not drawing at any one tap all the melted metal from the furnace, the danger of slag entering the tap hole is eliminated, and but one hole is necessary. Between the tuyères and opposite the tap hole, a square opening is provided to facilitate the sealing of the

* Metallurgist. Federal Mogul Corporation.



Diagrammatic Layout of Cushing Furnace Used in Connection with Barrett's Fixed Carbon Fuel for Melting and Refining Non-Ferrous Metals

bottom. Before starting the furnace this opening is bricked shut with exception of a small slot slightly below the level of the bottom of the tuyères through which slag may be drawn as it accumulates.

The air delivered to the tuyères is furnished by a belt driven, unloading type blower at a pressure of about 1/2 oz. A volume ranging between 300 and 400 ft.^{3}/min. has been found most satisfactory, and may be accurately adjusted by means of a gate in the delivery pipe. In operation the pressure and volume gages attached between the tuyères and the blower will be found to vary inversely to a small extent, as the charge in the furnace melts. A fresh charge containing considerable fine particle material slightly increases the pressure and decreases the volume of air delivered, but as the charge melts the volume gradually increases and the pressure decreases. This fluctuation is not nearly so marked with charges made up of sprues and runners and is almost unnoticeable when ingot metal is used.

Several different methods of charging are in use, depending upon conditions of installation. Charging from a platform is perhaps the most common. If there is sufficient head room the platform may be placed a foot or more above the level of the charging door and the charges dumped by means of a chute directly into the furnace. When there is not sufficient height to permit of this arrangement, the platform may be below the door and the fuel and metal shoveled into the furnace. A very satisfactory mechanical charger is used by several foundries, where the charges are made up on the floor and the container with both fuel and metal is elevated and emptied into the furnace in a manner similar to that employed with concrete mixers. With a battery of several furnaces in use, the platform above the charging door has the advantage of storage and easy inspection of the condition of the furnace which the mechanical charger does not permit. One elevator or hoist for the several furnaces is sufficient while with mechanical charging a lift for each furnace would be necessary.

Two methods of operation are in use. With one, the fuel bed is kept at an elevation of about 18 in. above the tuyères and the metal charge, usually about 500 lbs., is allowed to completely melt before another charge is introduced. With the other, the metal and fuel are charged in alternate layers to the level of the charging door and so maintained to the end of the day's run. With the former method it is easier to control analyses particularly when the charge is made of mixed metals with widely varying compositions. The whole charge being melted before another is added assures the desired composition of the liquid metal in the crucible. With the latter method, better efficiency and more rapid melting are possible but it is advisable to keep the components of the charge more nearly alike in composition else the smaller and more rapidly melted particles may greatly vary the analyses of the metal being drawn from the furnace. Where the charge is made up of metals similar in analysis and the melt can be drawn at uniform intervals from the crucible, this method of operation is by far the more desirable of the two.

During the writer's experience with a battery of these furnaces, a number of the well-known bronzes have been melted with, on the whole, remarkable success. The leaded alloys containing up to 10% of that element offer no serious difficulties, and there are installations where bronzes containing as much as 20% lead are successfully handled. However, where so much lead is present it would seem advisable to charge at one time an amount not in excess of what may be tapped into a single ladle.

Alloys containing much over 5% zinc do not appear to be economically handled by this furnace. The loss of zinc is quite heavy as the temperature at or about the tuyères is very high (approx. 3100° F.) and the metal passes through this section of the furnace in very small drops. The 85–5–5–5 bronze will lose over 60% of its zinc content in one melting, and although zinc is one of the inexpensive elements, the actual loss in compositions where this element is of high percentage, may be prohibitive.

The loss of lead at least on alloys containing 10% or under is not serious. It appears to be close to 8% of the amount present although with medium or very low lead contents the 8% figure is probably too great. As in the case with zinc this loss is partially, at least, due to volatilization, for increasing the fuel ratio has little effect upon it.

The losses in copper and tin are almost negligible if the particles of the charge are not sufficiently small to be carried up the stack with the blast. Phosphorus, free iron and free aluminum are almost entirely eliminated, but aluminum and iron in alloy form are not so severely affected. A phosphorus content as high as 0.15% is almost entirely lost in one melting. However, if a small charge be introduced and melted without air blast the loss in phosphorus may be more than cut in half. From this it would appear that the ultimate action of the furnace is slightly oxidizing in its nature, and that if advantage be taken of this, secondaries containing objectionable elements well up in the electromotive series, may be made to give satisfactory castings when melted in this type of furnace.

Figures for total cost of operation would be difficult to give and perhaps misleading as the labor required for melting will vary widely according to the character of installation. However, it is safe to assume that where a furnace is operated without hold-up for 8 or 9 hours, a fuel ratio of 1 to 14 may be expected. With the fuel costing approximately $33.00 per ton, this ratio would place the cost of melting at approximately 12¢ per 100 lbs. of metal melted.

Ajax-Wyatt Induction Furnace Patents Sustained by German Courts

A permanent injunction issued to Industrie Elektro-Ofen, Cologne, Germany, by the German Superior Court, Berlin, forbids them to further manufacture induction melting furnaces involving patents held by The Ajax Metal Co., Philadelphia. This follows the favorable decisions handed down in favor of The Hirsch Kupfer und Messingwerke, Finow (Mark), Germany, by the German Supereme Court I, Berlin, in October 1925 and November 1927. The Hirsch Kupfer und Messingwerke are the European manufacturing agents for The Ajax Metal Company.

The Court has ordered the Industrie Elektro-Ofen (who marketed an induction furnace under the trade-name of Russ) to make full financial restitution to Hirsch Kupfer und Messingwerke. The situation in the induction furnace field thus finds the Ajax-Wyatt Furnace in a dominating position.

Calendar of Meetings

American Chemical Society, Intersectional Meeting, Buffalo N. Y., Nov. 28, 29.

American Institute of Chemical Engineers, New Orleans, La., Dec. 8–10, 1930.

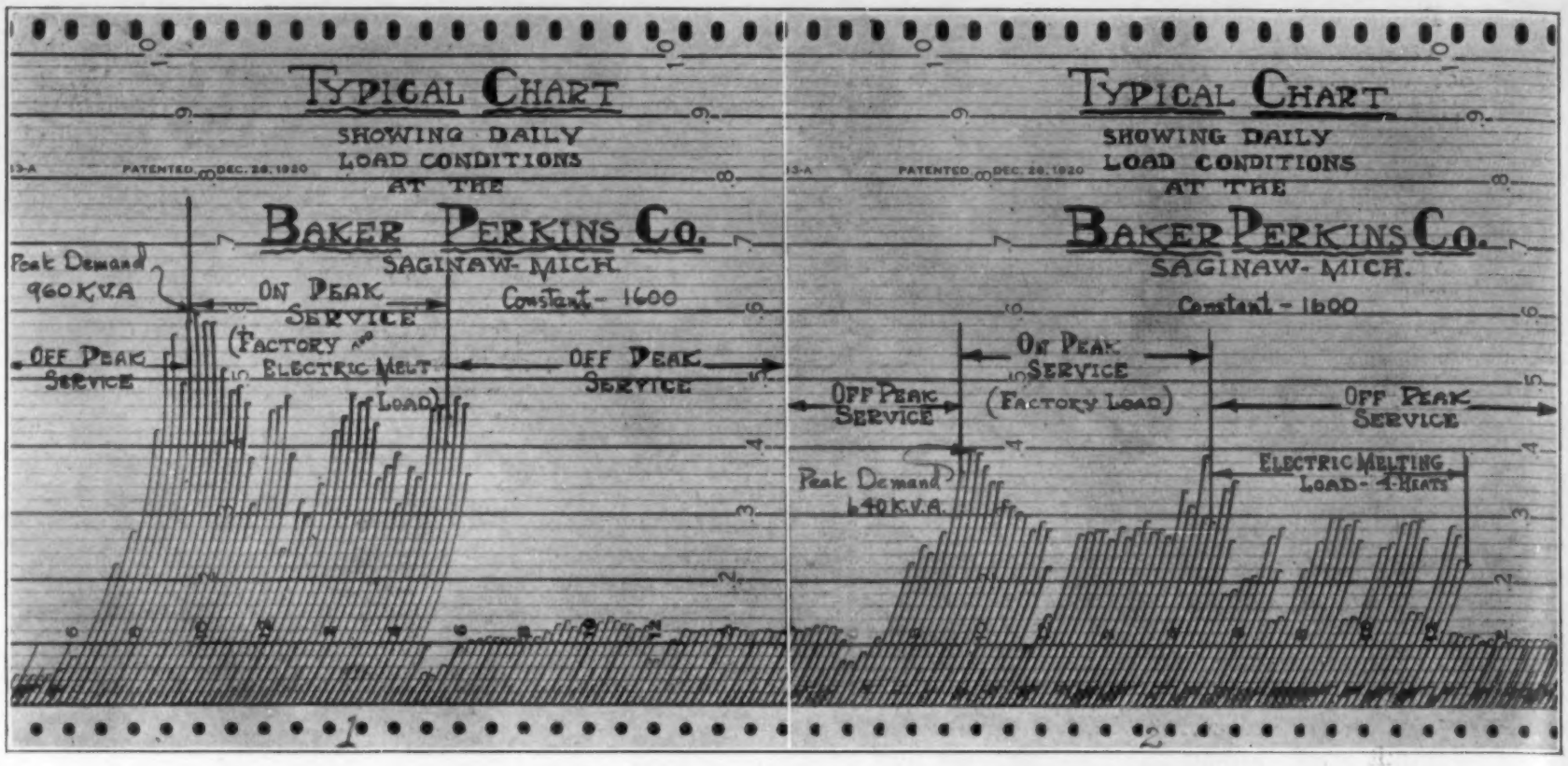
Association for the Advancement of Science, Cleveland, Ohio, Dec. 29–Jan. 31, 1931.

National Western Metal Congress and Exposition, San Francisco, Cal., week of Feb. 16, 1931. .

American Electrochemical Society, Hotel Tutwiler, Birmingham, Ala., April 23–25, 1931.

Thirteenth Exposition of Chemical Industries, Grand Central Palace, New York, Week of May 4th, 1931.

The Hoskins Mfg. Co., Detroit, Michigan, manufacturers of resistance wire, electric furnaces and pyrometers, announce the appointment of Mr. E. A. Wilcox as their representative in California. The address is 273 Seventh St., San Francisco.



USING OFF-PEAK POWER

for Melting Gray Iron

By W. R. Jennings*

It has often been suggested by economists (power company as well as academic) that a considerable saving on electrical unit cost could be made, if manufacturers would take advantage of the off-peak power rates.

The Baker-Perkins Co. of Saginaw, Michigan, has been operating a rocking type electric furnace on cold stock melting of gray iron for a period of 4 months. The results are highly satisfactory. Iron borings, formerly a drug on the market are now converted into high strength irons. A considerable reduction was made in foundry scrap, and shop rejects were practically nil. Costs of metal at the spout compared favorably with cupola metal. However, the principal cost item on any cost sheet was power.

Due to the increased demand charge our electrical energy for melting costs from 1.6 to 1.7 per kwh. This at an average of 590 kwh. per ton, gave us a melting cost of $9.44 to $10.03 per net ton melted.

A study of our power charts showed that a decided saving could be made if the furnace was operated at night. But a change of this sort raises some serious questions. What effect would this change have on labor rates? How would it affect quality of workmanship? And how would it affect production? The type of installation, class of work, working conditions, and the type of men employed, must be considered to understand the simplicity with which this radical departure was made.

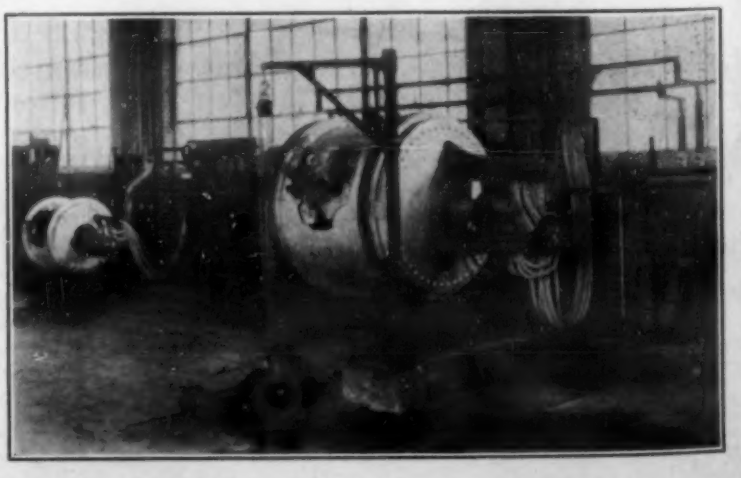
The installation is unique in that it comprises more or less a separate unit within the foundry proper—a separate foundry one might say, consisting of the electric furnace as a melting unit—one foreman, one melter, one iron pourer and 5 to 7 bench molders (skilled mechanics).

The work produced is mostly loose pattern type castings running from 1 oz. to 20 lbs. in weight and in quantity from 1–10 pieces; a plate job is very much the exception. The problems because of the compactness of the group were quite easily disposed of by frank discussion. All the points: the necessity for making the change, objections, etc., were settled before the program was initiated.

No change was made in the labor rate, the men accepting the changed working hours without objection. In fact, this shift is now preferred over the regular day shift. The molders are on a 5-day week starting at 3 P. M. and working until 12 midnight with $1/2$ hour for lunch.

The quality of the work was maintained because of a piece work system under which the molders were paid for good castings produced. For the same reason the quantity produced did not drop off.

The charts as given are typical, showing the load conditions. Before the Detroit Electric Furnace load was added to the factory load, a demand of approximately 650 kva. was required for normal operations. By operating the electric furnace during the day, the demand was raised to 960 kva. (see Chart No. 1). In order to decrease the demand charge, the electric furnace unit of the foundry changed the time of operation from 7 A. M. to 4 P. M. to that of 4 P. M. to 12 mid-



Installation Consisting of One Type AA—750 to 1000 lbs. Capacity Detroit Furnace and one Type LFS—250 lbs. Detroit Furnace in the Plant of the Baker-Perkins Co., Saginaw, Michigan

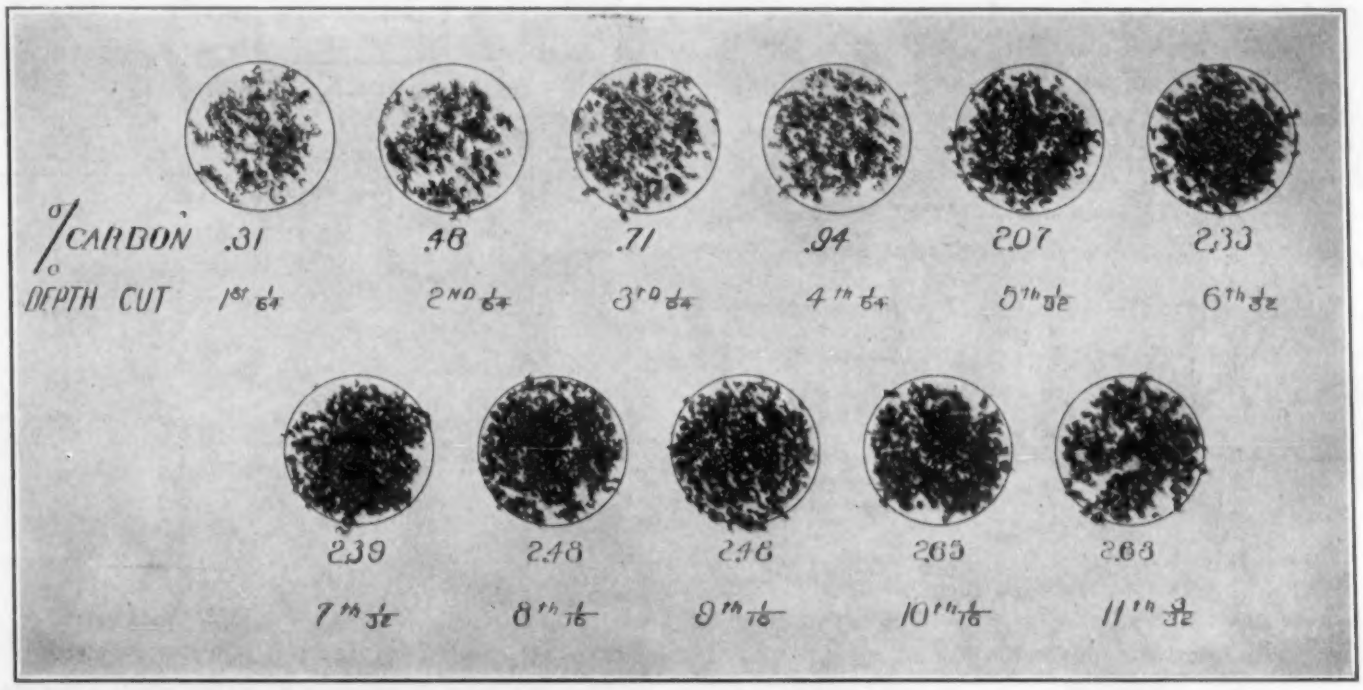
* Foundry Superintendent, Baker Perkins Company

night (the molders start work one hour ahead of the furnace and thus maintain a steady flow of work for the furnace).

By making this change, the daily peak demand was reduced but the load factor of the plant was greatly increased (see Chart No. 2). As a result of this, the cost per kwh. for electrical energy was reduced. The "typical charts" show before and after conditions of plant operation. The demand was reduced from 960 kva. to 640 kva., a difference of 320 kva. which represents a saving in demand charge of $5500.00 per year. By taking advantage of the power company's off-peak service, namely, between the hours of 4 P. M. and 8 A. M., the cost chargeable against the electric furnace operation is for the energy used alone. This energy is approximately one cent per kwh. Using 590 kwh. per heat, the cost of electrical energy per pound is 0.00295 cent.

Carbon Loss and Diffusion in the Malleablizing Process

By Enrique Touceda



While it is well known that during the malleablization of white iron castings a certain percentage of the carbon content will be eliminated, but little data is available covering the extent to which this will take place in the case of hard iron castings of different carbon content when subjected to an average 7-day annealing cycle, or the variation in carbon content from surface to that depth where apparently the carbon remains constant.

In order to make a start on an investigation of this matter, a set of 8 hard iron blocks, $3\frac{1}{2}'' \times 1\frac{3}{4}'' \times \frac{3}{4}''$, were secured, in which the carbon varied from 1.99% in the one of lowest carbon content to 2.66% in the highest. Each block was made by a different plant.

These blocks were surface ground prior to heat-treatment in order that there would be available a perfect surface for the cutting tool during the removal of the first $\frac{1}{64}''$ cut.

All of the blocks were placed close together in the second ring from the bottom in a stand located in the center of the oven, in a packing consisting of a mixture of burnt molding and tumbling barrel sand, and subjected to what can be considered as an average annealing (heat-treating) cycle.

A section of each block was prepared for microscopical examination in order to make sure that the structure in each case was normal. Each block was found to be free from "frame," from primary graphite and from shrink.

Four successive cuts of $\frac{1}{64}''$, followed by three of $\frac{1}{32}''$; three of $\frac{1}{16}''$ and one of $\frac{3}{32}''$ were made over the entire $3\frac{1}{2} \times 1\frac{3}{4}$ face of the block. In the case of each cut the entire amount of drillings was saved; thoroughly ground and mixed together for the sample for analysis.

The machining was done somewhat closer than a thousandth of an inch, while in all cases the carbon analyses were done by combustion and checked.

In the table that follows is recorded the carbon analysis of each cut; the carbon content of each block prior to their heat-treatment and the analysis of the malleablized blocks.

In the accompanying photograph is shown the character of chips from each cut.

Percent of Carbon in Each Cut

Cut	Depth	Block No. 1	Block No. 2	Block No. 3	Block No. 4	Block No. 5	Block No. 6	Block No 7	Block No. 8
1st	1/64"	0.45	0.39	0 31	0.53	0.33	0.49	0.25	0.31
2nd	1/64"	0.70	0.62	0.50	0.77	0.53	0.66	0.27	0.46
3rd	1/64"	0.73	0.70	0.71	0.96	0.74	0.73	0.41	0.71
4th	1/64"	0.83	0.89	1.44	0.98	1.52	1.10	0.86	0.94
5th	1/32"	1.50	1.73	1.90	1.87	2.13	2.00	1.92	2.07
6th	1/32"	1.66	2.02	1.96	2.10	2.23	2.17	2.38	2.33
7th	1/32"	1.68	2.11	1.99	2.14	2.31	2.26	2.43	2.39
8th	1/16"	1.80	2.18	2.14	2.20	2.30	2.28	2.47	2.48
9th	1/16"	1.86	2.21	2.17	2.24	2.33	2.29	2.48	2.48
10th	1/16"	1.87	2.21	2.30	2.37	2.38	2.29	2.49	2.65
11th	3/32"	1.89	2.20	2.29	2.36	2.36	2.37	2.65	2.63
Carbon in Original Hard Iron Blocks									
——	——	1.99	2.20	2.25	2.37	2.43	2.50	2.58	2.66
Analysis of Malleabilized Blocks									
Carbon		1.64	2.00	1.96	2.03	2.09	2.05	2.18	2.23
Silicon		1.06	0.81	1.10	1.11	0.90	0.95	1.04	0.79
Phosphorus		0.176	0.217	0.183	0.187	0.140	0.176	0.150	0.167
Sulphur		0.060	0.112	0.079	0.083	0.092	0.099	0.079	0.067
Manganese		0.232	0.232	0.255	0.278	0.232	0.371	0.371	0.284

The data in the Table indicates that during malleablization there is an average loss of carbon of 0.35% actual. The loss sustained was least in Block 2, which amounted to 0.20% actual, and the greatest in Block 6 in which the loss was 0.45% actual.

In 6 of the samples the elimination is greatest between the surface and a depth of $\frac{1}{16}''$, when the change in carbon content becomes abrupt. In blocks 3 and 5 the abrupt change takes place at a depth of $\frac{3}{64}''$.

There exists nothing in the composition of these 2 blocks that would serve to explain why the abrupt change should take place at a less depth than obtained in the case of the other six.

Inasmuch as the cuts were carried down to the middle of the section, and as the carbon appears to remain fairly constant in most of the blocks in the vicinity of that depth, it perhaps may be safe to assume that had the blocks been of 1" instead of $\frac{3}{4}''$ thickness, there would have been a $\frac{1}{4}''$ central portion of constant carbon content, that is, it would appear from the results of this one set, that a diffusion of the carbon toward the surface practically ceases at a depth of about $\frac{7}{16}''$.

The METALLURGICAL LABORATORIES of the Ontario Research Foundation

By Richard Rimbach*

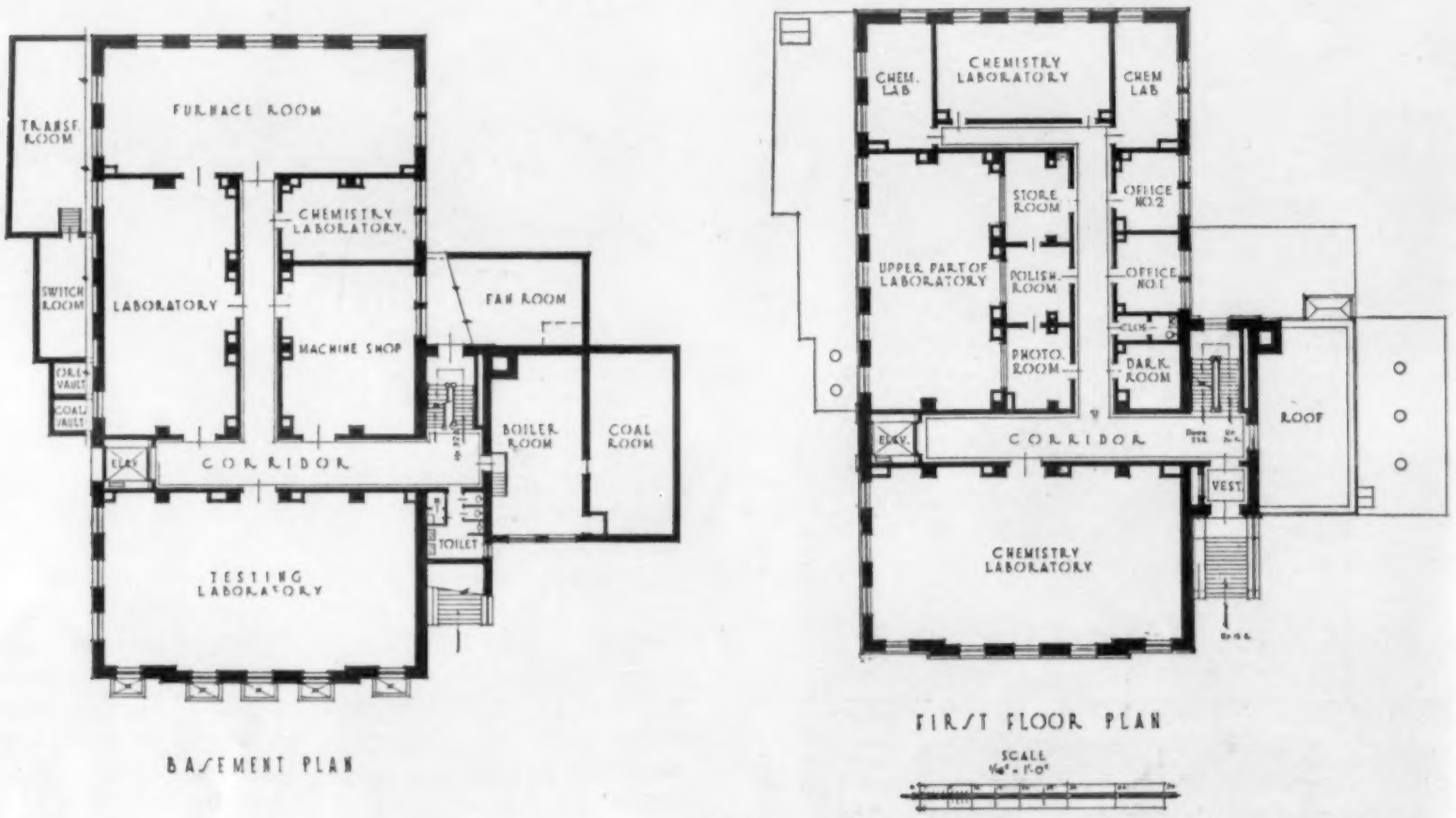


Fig. 1

On the 30th of March, 1928, an Act to Establish a Research Foundation in Ontario received the royal assent. As a result, the efforts of the Premier of Ontario, Hon. G. Howard Ferguson, to obtain the consent of the legislature of the Province of Ontario to establish a foundation for the carrying out of research work and investigation, bore their fruit.

In the Act the objects of the foundation thereby created were described as follows:

(*a*) the improvement and development of manufacturing and other industries by the introduction of advanced methods and processes;

(*b*) the discovery and better development of the natural resources of the Province and the discovery and utilization of the by-products of any processes in treating or otherwise dealing with the mineral, timber and other resources of the Province;

(*c*) the development and improvement of methods in the agricultural industry and the betterment, welfare and progress of farm life;

(*d*) scientific research and investigation for the mitigation and abolition of disease in animal or vegetable life and the destruction of insect or parasitic pests;

(*e*) generally the carrying out, with the approval or under the direction of the Lieutenant-Governor in Council, of any other research work or investigation which may be deemed expedient.

Not only was the Foundation brought into being through the provisions of this Act, but means were also devised for its financial support. The scheme laid down was to all intents and purposes that the Treasurer of the Province should match dollar for dollar with individuals and corporations throughout Ontario until the sum of $1,000,000 had been subscribed. The response was so phenomenal that the Act as originally passed had to be amended just about a year later, the amendment altering the above-named sum to $2,500,000. At the present time, from both sources the sum of approximately $3,800,000 has been placed at the disposal of the Foundation.

One of the first laboratories to be installed was designed to meet the requirements of the textile industries of Ontario. Soon afterward, a laboratory devoted to the problems of certain packing industries was equipped. Then, in the fall of 1928, the formation of a metallurgical division was suggested by the Ontario Chapter of the American Society for Steel Treating through the medium of a research committee which was appointed to confer with Sir Joseph Flavelle and Dr. H. B. Speakman, chairman and director, respectively, of the Foundation. As a result of their deliberations, two things issued. In the first place, Mr. O. W. Ellis was appointed Director of Metallurgical Research; and in the second place, immediate steps were taken to organize laboratories for the carrying out of metallurgical investigation. Owing to certain developments which need not be referred to here, it appeared necessary that a building designed to contain laboratories for chemical and metallurgical investigations should be erected at the earliest possible moment. This work was undertaken largely after the appointment of Mr. Ellis to his position. Plans were drawn up and in due time received the approval of the Chairman with the result that

* Associate Editor.

the corner-stone of the new building was laid by the Premier of Ontario, Hon. Mr. Ferguson, on September 28th, 1929. This building, the architect's plans for which are shown in Fig. 1, was completed early this year, and the members of the Metallurgical Division entered into possession of their laboratories on the 1st of March.

Reference to Fig. 1 will show that the floor space in the basement of this new building is divided into five main parts. Reference may well be made to these various parts in order:

(1) The laboratory on the east side of the building extends through both floors and gives a working space of $19^1/_2$ feet between the floor of the laboratory and the 5-ton crane which has been installed. In this laboratory semi-commercial scale tests on ores, fuels, etc., will be conducted by members of the metallurgical and chemical divisions. A photograph of this laboratory is shown in Fig. 2, in which can be seen the switchboard controlling the electrical equipment throughout the building. A large number of the switches in this board are intended for future use, the building being designed to extend ultimately to four stories. (A front elevation of the projected building is shown in Fig. 3, which may be compared with Fig. 4, the latter being a photograph of the building as it is at present.)

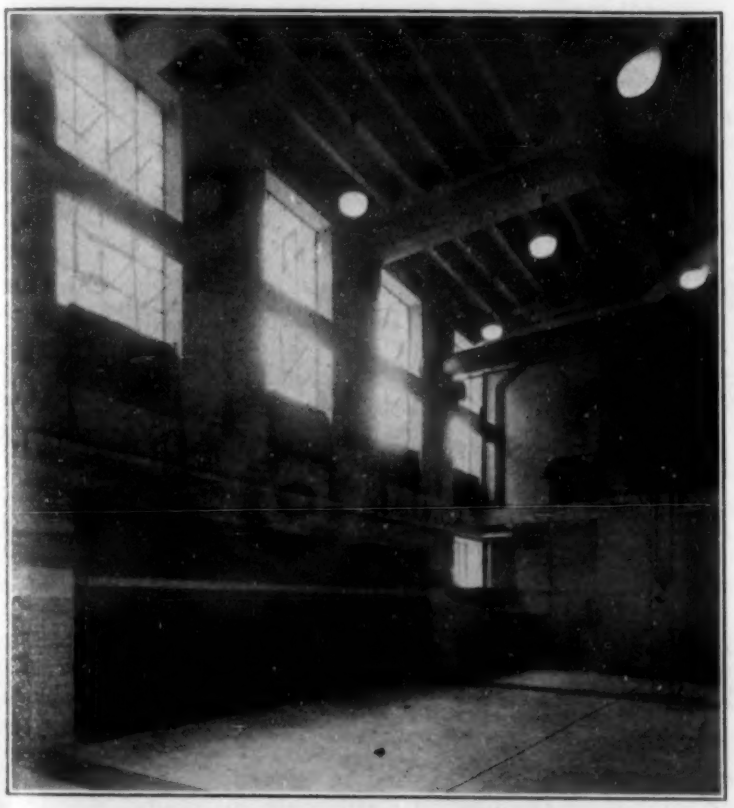


Fig. 2

Behind the switchboard shown in Fig. 2 is a switch room through which access may be had to a transformer room. Here power entering at 2300 volts is stepped down in three oil-cooled transformers to 550 volts, which in turn is stepped down by air-cooled transformers situated in the switch room to 220 and 110 volts. The power is supplied at 25 cycles. Not only is alternating current available for use in the building, but direct current also at the two voltages, 110 and 220.

Two small vaults adjoin the two-story laboratory, these being designed to contain ore or fuel brought to the Foundation for investigation. Access to these vaults may be had from the driveway which skirts the east side of the building, so that a minimum of haulage is required for the disposal of such material. On the east side of the building, entrance is provided through a 5-ton elevator, so that heavy machines and cumbrous parts that are sent in for testing and investigation may be brought in without undue difficulty. The corridors, both in the basement and on the first floor are amply wide and are so arranged that large parts can be readily brought into and out of the various rooms.

(2) At the north end of the building is a mechanical testing laboratory, 65 feet long by 35 feet wide, in which at the present time there are in constant use a 50,000-lb. Amsler universal testing machine equipped with a load maintaining device, two Avery fatigue-testing machines designed for testing

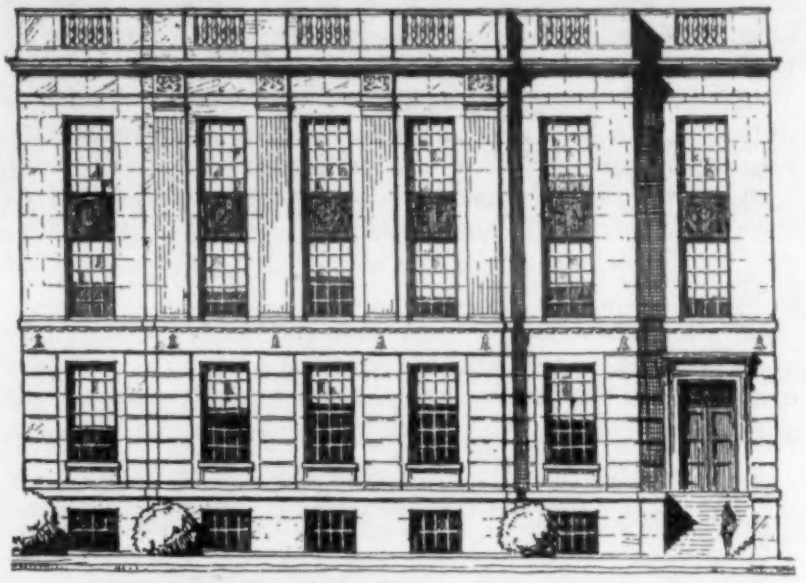


Fig. 3—Laboratories of Ontario Research Foundation

cantilever test pieces of standard British design and also test pieces of a type commonly used in the United States, and two other fatigue-testing machines designed to take test pieces of the beam type. These machines are capable of taking two test pieces each. An Amsler impact testing machine, designed to take both Izod and Charpy test pieces, is also situated in this laboratory. Hardness-testing machines of the Brinell, Rockwell and Vickers types are likewise placed here. There is ample room for the introduction of other testing equipment, to be provided in the near future.

The Foundation, however, is in the happy situation of being able to utilize the mechanical testing equipment at the University of Toronto through the courtesy of those in charge.

A considerable amount of work has already been carried out in the mechanical testing laboratory, including investigations of the causes of failure of heavy turnbuckles and of the effect of nickel on bronze. The latter work is being proceeded with at the present time and is one of the principal subjects of investigation by the Metallurgical Division.

A photograph of a portion of the mechanical testing laboratory is shown in Fig. 5.

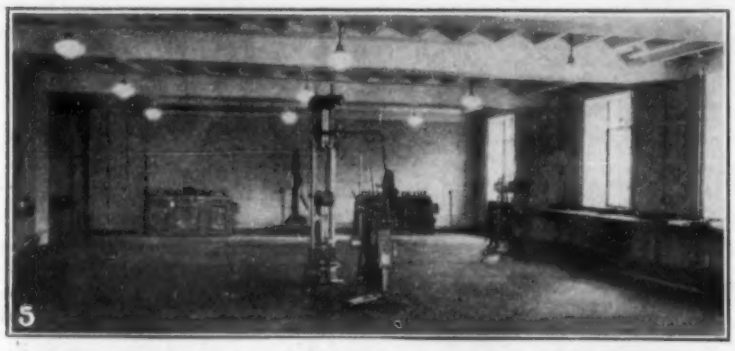
Fig. 4

(3) At the south end of the basement is the furnace room where provision is made not merely for the heat treatment, but also for the melting and casting of metals and alloys. Here is installed a 35-kva. converter system coupled with an induction furnace which has already found use in the melting of certain alloys. This furnace is shown in Fig. 6, at the far end of the laboratory. Alongside is a 50-kw. Globar furnace. This furnace has not only proved useful in the heat

treatment of certain steels, but has been of considerable value in the preparation of bronzes and alloys which have been looked upon hitherto as having relatively high melting points. The usefulness of this type of furnace in this connection can scarcely be emphasized too much; the fact that the temperature can be controlled so readily makes its use in control work on non-ferrous alloys extremely valuable. A large box-type furnace with metallic resistors, is available for the heat treatment of metals and alloys at temperatures up to 1850° F. To complete the furnace equipment, there is also in this room a Homo furnace for the drawing of steel and the heat treatment of alloys of low melting point.

(4) Next to the furnace room is a laboratory equipped for the analysis of metallurgical materials brought to the Foundation for investigation, and of alloys, etc., produced in the furnace room.

(5) To complete the equipment of the basement, a machine shop has been installed, provided with a range of machine tools sufficiently wide to cover practically all the needs of metallurgical practice. Here test pieces may be prepared,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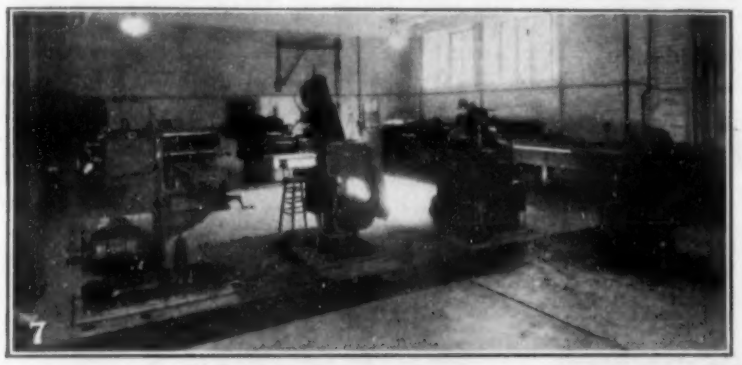
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Figs. 5, 6 and 7

micro-samples partially prepared for microscopic investigation and other equipment built for special purposes in the various laboratories. A photograph of the machine shop is shown in Fig. 7.

It should be mentioned that there is room in both the machine shop and the furnace room for other equipment, before long means will be provided for the rolling, swaging and drawing of metals.

Of the first floor of the building only part is devoted to metallurgical investigation. In Fig. 1 it will be noted that three rooms on this floor are referred to as "store room," "polish room" and "photo room," respectively.

The first is devoted entirely to the physical investigation of metals and alloys. Here is situated the necessary equipment for the taking of cooling curves, and communication is made from this room to the furnace room so that, when necessary, checks can be made of furnace temperatures and cooling curves taken of metals and alloys in course of preparation in the furnace room. Thus, the more delicate potentiometric equipment, ordinarily used for high grade experimental work, can at a stretch be employed in the furnace room without the connection in any way proving harmful or destructive.

In the polishing room is found such equipment as is necessary for the preparation of micro-samples. The photomicrographic laboratory is equipped with one of the most recent of the Zeiss photomicrographic machines. This, naturally, has already seen considerable service. A Bausch and Lomb microscope for the examination of samples in course of polishing is also available in this group of laboratories.

The dark room is situated opposite the photomicrographic room, on the other side of the corridor. This is fully equipped with all conveniences necessary for rapid work and is available for use by all divisions of the Foundation.

The office of the Director of Metallurgical Research is situated opposite the polishing room and is thus in immediate contact with the work on this floor.

In the older building of the Foundation there are library and reading facilities, so that it is seldom necessary for members of any division to leave the Foundation in order to obtain technical information from the literature on any subject connected with their work. However, the Foundation is within a few hundred yards of the University library, which is very complete.

Since the Metallurgical Division was organized, no fewer than 29 problems of considerable importance to the metallurgical industries of Ontario have been dealt with. Some of these problems have lead to the formulation of research programs which are now under way, and it is becoming daily more clear that the Foundation, through the medium of this division, is amply fulfilling the purpose for which it was created.

Fourth National Fuels Meeting Program Nearing Completion

The program for the Fourth National Fuels Meeting of the A. S. M. E. which will be held in Chicago, February 11–13, 1931, is rapidly nearing the stage where papers and authors for each session may be announced.

The Fuels Division of the American Society of Mechanical Engineers, which has sponsored these national events since their inauguration in 1927, is making an unusual effort to develop the type of program best fitted to parallel the sessions of the Midwest Power Engineering Conference to be held during the same week. The procedure for the Fourth National Fuels Meeting will be somewhat different from that followed at the three previous meetings. Heretofore, the meetings have started on Monday morning and have run four days with as high as three simultaneous sessions during some of the periods. The coming Meeting will start on Wednesday afternoon, and both the Fuels Division and the Chicago Section of the A. S. M. E., which is in charge of all local arrangements, have agreed that there must be no simultaneous sessions.

For the first time in the history of the meetings a parallel convention will operate during two days of the three-day event. However, both programs have been so laid out that there will be no conflicting sessions and the engineer interested in both fuels and power can arrange his schedule so that maximum results may be had.

Among the subjects included in the program in its present form are the following:

"Developments in Furnace Design"
"Developments in Pulverized Fuel Firing"
"Developments in the Small Stoker Field"
"The Use of Refinery Waste Fuels"
"The Use of Natural Gas and the Conversion of Coal Fired Furnaces to Gas"
"Boiler Efficiencies as Effected by Types of Fuels"
"Effect of Temperature on Rapidity of Combustion"
"Heat Absorption as Effected by Furnace Wall Materials"
"Selection and Coördination of Steam Generating Equipment"
"Design and Performance of Large Boiler Units"
"The Boiler Plant of the Future"
"Changes in Character of Mid-West Coals and Stoker Performances"
"Air Pollution"

Origin and Effect of Inclusions in Steel†

A Review

By B. M. Larsen*

(*Continued from October*)

XIV. Methods of Extraction of Non-metallic Inclusions

A list of the possible methods of extraction of non-metallic inclusions from steels would include the following:

1. Mechanical separation, based upon the difference in physical properties between inclusions and iron.
2. Removal of iron by various solvents, depending upon differences in solubility or in rates of solution.
3. Solution of the iron as the anode in an electrolytic-cell, depending on the large solution pressure of the iron, manganese, etc., in the metallic state as compared to the oxides or carbides of these metals.

Mechanical Separation

Snelus[46] pounded up samples of borings from muck bar in an iron mortar. The brittle slaggy matter became pulverized and could be largely separated from the flattened pieces of iron by screening through a fine sieve. It is barely possible that such a method might be applied to steels if the metal could be made very brittle by cooling in liquid air, impregnating with hydrogen, or some such method. However, the very small percentage of inclusions present (usually around 0.001–0.050% in commercial samples) would seem to make anything approaching a quantitative separation in this way practically impossible. Assuming the sample to be obtained in a very finely divided form, it would then be necessary to separate iron and iron carbide from the inclusions by some ore-dressing method. Magnetic separation might be used, if it could be made so nearly perfect as to give an approach to a quantitative recovery of the non-magnetic or oxide portion of the sample. The float and sink method, using heavy liquids, would be the most suitable in this case, but for the fact that no liquid seems to be available with a specific gravity around 6.0, which would be necessary to separate FeO and MnO sp. gr. about 6.0 and 5.5) from Fe_3C and Fe (sp. gr. 7.67 and 7.86).

Extraction by Differential Solvent Action

A large number of methods of this general type are described in the literature, the earliest being probably the iodine method used by Eggertz[47] as early as 1867. The results obtained by the earlier experimenters are nearly all covered and augmented by the recent articles of Oberhoffer and Ammann,[48] Westcott,[49] Willems,[22] and Herty and Fitterer,[23] and it should not be necessary to go into detail here concerning them. Ledebur[50] and Barrows and Turner[51] treated iron drillings with purified chlorine gas at low red heat in a combustion furnace, the iron forming $FeCl_3$ which volatilized and was carried away in the gas stream. Barrows and Turner showed that the chlorine reacted with FeO according to the reaction,

$$3FeO + 1^1/_2Cl_2 = Fe_2O_3 + FeCl_3 \qquad (33)$$

giving low results on material containing inclusions high in FeO, such as wrought iron. At still higher temperatures (described as a red heat, perhaps around 700–800° C.) the same authors reported evidence of direct reaction between Fe_2O_3 and the chlorine.

This method has the disadvantages of being a little complicated, besides apparently requiring that the sample be rather finely divided. In the process of drilling or milling a sample, the more brittle slag particles are always liable to be broken up to some extent, so that microscopic examination of the residue from extraction is less valuable than when a sample composed of more massive pieces is treated. Such a sample might possibly be used in this method, however. $FeCl_3$ has a vapor pressure equal to one atmosphere at around 300° C. If a lower temperature were used it is possible that the decomposition of FeO by chlorine might become negligible. If a more massive sample could be decomposed within a reasonable length of time at a temperature of, say, 350–400° C., then this method would become more promising.

Acid Solvents

If a steel sample is heated with moderately concentrated HCl or HNO_3 solutions until all the iron is dissolved, the residue will contain perhaps roughly 80–90% of the Al_2O_3 and a large part of any silica or high-silica silicate inclusions originally present in the sample. By using dilute acid, cooling and agitating the solution, we have essentially the method used by Stead and by Dickenson[52] and modified and studied by Herty and Fitterer.[23] Ten per cent HNO_3 solution is cooled by running water and agitated by bubbling air through it, the residue being later treated successively by boiling solutions of $KMnO_4$, 5% HCl and 10% NaOH to remove residual carbon and iron carbide, basic salts of iron and colloidal silicic acid, Kichline[53] used an HCl solution (about 5 M), heated gently, to determine Al_2O_3. This method probably did not give better than 90–95% recovery of the alumina inclusions.

These methods using acid solutions all apparently depend upon the differences in *rate of solution* between the metallic and non-metallic phases present. Apparently in the Dickenson method, sulphide inclusions, free FeO or MnO, and silicates or aluminates containing 50–70% or more of these oxides are largely decomposed by the acid. According to Herty's results,[27] good recoveries of inclusions of SiO_2, Al_2O_3 or silicates high in silica are obtained. Since in killed steels these latter types of inclusions usually occur, such a method has considerable usefulness but even in such steels the results are not quantitative and are always somewhat uncertain. In the Dickenson method, insufficient agitation and the oxidizing acid used favor the formation of basic salts in the fluid film on the iron surfaces where the solution action occurs and through which the products of reaction must diffuse. In the latter treatments with 5% HCl sol. much additional attack upon the slag particles often occurs. The

† Part III, Part I published in September. Part II published in October.

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[47] Eggertz, A., Method for the Determination of Silicon in Iron and Steel. *Engineering*, Vol. 5 (1868), pages 71, 91. A translation.

[48] Oberhoffer, P., & Ammann, E., Ein Beitrag zur Bestimmung oxydischer Einschlüsse in Roheisen und Stahl. *Stahl und Eisen*, Vol. 47 (1927), pages 1536–1540.

[49] Westcott, B. B., Eckert, F. E., & Einert, H., Determination of Slag and Oxides in Wrought Iron. *Industrial & Engineering Chemistry*, Vol. 19 (1927), pages 1285–1288.

[50] Ledebur, A., Sauerstoffbestimmung im Schmiedbaren Eisen. *Stahl und Eisen*, Vol. 2 (1882), pages 93–198.

[51] Barrows, A. E., & Turner, T., Estimation of Slag in Wrought Iron. *Journal Chemical Society*, Vol. 61 (1892), pages 551–557.

[52] Dickenson, J. H. S., A Note on the Distribution of Silicates in Stee Ingots. *Journal Iron & Steel Institute*, Vol. 113, No. 1 (1926), pages, 177–211.

[53] Kichline, F. O., Note on the Determination of Aluminum Oxide and Total Aluminum in Steel. *Industrial & Engineering Chemistry*, Vol. 7 (1915), pages 806–807.

treatment with boiling NaOH sol. probably dissolves some silica from silicates in addition to that present as colloidal silicic acid.

A modified and much shortened procedure similar to that of Dickenson's would be simple and perhaps useful for certain types of steel and for many works analyses. Such changes as the following suggest themselves:

1. More vigorous agitation by shaking or cascading the solution and the use of more concentrated acid or some acid mixture to prevent the formation of basic salts.

2. Treatment with 5% sodium carbonate solution instead of the 10% NaOH, to prevent solution of some of the crystallized silica.

3. Filtration through cellulose colloid filters, or through finely porous, sintered glass or porcelain plates, or separation by a centrifuge, so that the residue could be dried and weighed without the necessity of a long period of settling and decantation.

Neutral Solvents

Following the original iodine method of Eggertz, many methods are described, based upon the solvent effect on iron of neutral aqueous solutions of iodine, bromine, ferric chloride, mercuric chloride or cupric ammonium chloride. Oberhoffer and Sherer[54] and Oberhoffer and Ammann[48] introduced numerous refinements into the bromine method. Westcott[49] and Willems[22] used and developed the iodine method. Little attention seems to have been given to the use of iron, mercury and copper chloride solutions in the more recent work. Water was the solvent used in all these methods except the last method introduced by Willems, using iodine dissolved in absolute alcohol.

In all such aqueous solutions, the pH of the solutions will be somewhat less than 7.0, if for no other reason, because of the hydrolysis of the ferrous and ferric salts formed in solution. The results of Westcott[49] indicate that in aqueous I_2–KI solutions, FeO in the form of fayalite ($2FeO \cdot SiO_2$) is not much attacked by such weakly acid solutions. The results of Oberhoffer and Ammann[48] and of Willems[22] indicate that MnO and FeO are partly dissolved in aqueous I_2–KI and Br_2–KBr solutions. MnO was apparently attacked more rapidly than FeO. Willems, however, was apparently able to obtain a nearly quantitative recovery of MnO by using a solution of iodine in absolute alcohol. Even when the solvent used was 95% alcohol, the 5% of water present together with the dissolved FeI_2, formed sufficient hydriodic acid to dissolve some of the MnO inclusions. In the absence of metallic iron, even aqueous iodine solutions did not dissolve MnO, indicating that the cause of solution was really the hydrogen ions formed by hydrolysis of the iron salts when water was present.

Contamination of the residues by precipitated basic or oxysalts of iron was also encountered in these experiments, but neither the composition of these salts nor the exact mechanism of their formation was determined. The effect could apparently be lessened by rapid shaking of the solutions and by keeping them out of contact with the air.

In all these methods, good results are favored by shortening the time necessary for complete solution of the iron. Perhaps the most important factor limiting the rate of solution is the thickness of the relatively motionless film of liquid in contact with the iron surfaces through which the reactants and products of reaction must diffuse. This film should vary in thickness with the viscosity of the solution (which may be decreased by raising the temperature) and with the velocity of motion of the main body of solution (which, of course, may be increased by shaking or stirring).

Very tiny particles are always likely to be found as inclusions in steels, and in any method involving filtration, very finely porous filters must be used. The sintered glass filter probably has the disadvantage that it would be difficult to remove all the dried residue from the plate without washing or solution in acids. Collodion covered paper or filter paper covered with fine paper pulp may be used if the residue is to be ignited. Parchment paper such as is used in dialysis experiments might be used, or a collodion filter which could later be dissolved in ether. Willems[22] used a "cella-filter," a cellulose filter which has been developed in Germany by E. Kartz, Göttingen.

Of the methods mentioned above, the bromine method as described by Wescott[49] or Ammann[48] should be suitable in cases where not much of free FeO and especially of MnO are present in the inclusions. These oxides are, however, the essential constituents of the inclusions in many commercial steels, especially in the class known as "rimmed steels." In such samples it is necessary to use an electrolytic method or one similar to the iodine-absolute alcohol method described by Willems.[22]

Electrolytic Methods

Herty and Fitterer[55] have discussed the problems involved in extracting inclusions by making the sample the anode in an electrolytic cell. They were not able to obtain quantitative recovery of MnO, and checked the conclusion of Willems[22] that MnO is soluble in even neutral aqueous solutions of iron salts. Very many combinations of electrolyte, current density, and cell set-up are possible, however, and it seems quite probable that an electrolytic method will be found that will recover the more soluble inclusions, such as FeO, MnO, FeS, etc.

XV. Effects of Inclusions on the Properties of Steel

The data on the effects of inclusions in finished steel are so haphazard and conflicting that the most reasonable way of presenting them seems to be simply as very brief abstracts from the various articles available on the subject.

Burgess and Quick[56] compared physical properties of rails from two open-hearth heats, one finished in the usual way with ferro-silicon and ferro-manganese, and the other treated with ferro-manganese and ferro-carbon-titanium. The titanium tended to scatter the sulphide inclusions and in the larger amounts appeared to combine with some of the nitrogen to form very small violet and orange inclusions. It also reduced the segregation in the upper part of the ingot from which the A rail was rolled, and improved the mechanical properties slightly but these differences disappeared before the B rail was reached.

Atkins[57] extracted tiny crystalline particles of alumina from wire rod steels and studied the properties of various lots in the making of which various amounts of aluminum were added in the ladle before pouring. Increased alumina contents caused the dies to wear badly, so the diameter of the wire increased quite rapidly as drawing progressed through one die. Bad segregates of inclusions occasionally caused "necking down" in place. Certain lots of steel showed a tendency to form V-shaped tears in the center of the drawn wire, and sulphur prints of the billets showed pronounced segregation between rim and core sections of what was apparently rimmed steel. Bad surfaces on wire may often result from either inclusions or skin blowholes.

Giolitti,[58] throughout his book on heat treatment of soft

[54] Sherer, R., & Oberhoffer, P., Die Bestimmung des Sauerstoffs im Eisen. *Stahl und Eisen*, Vol. 37 (1925), pages 1555–1557.

[55] Herty, C. H., Fitterer, G. R., & Marshall, W. E., Theoretical Considerations in the Electrolytic Determination of Non-Metallic Inclusions in Steel. *Cooperative Bulletin* 44, *Mining & Metallurgical Advisory Boards*, Pittsburgh, Pa. (1929).

[56] Burgess, G. K., & Quick, G. W., A Comparison of the Deoxidation Effects of Titanium and Silicon on the Properties of Rail Steel. *U. S. Bureau of Standards Technical Paper* No. 241 (1923).

[57] Atkins, E. A., The Drawing of Steel Wire and its Relation to Qualities of Steel. *Journal Iron & Steel Institute*, Vol. 115 (1927), pages 443–482.

[58] Giolitti, F., Heat Treatment of Soft and Medium Steels. McGraw-Hill Book Company, Inc., New York (1921).

and medium steels, mentions repeatedly the bad effects of excessive amounts of inclusions, such as the lower ductility, woody and flakey fractures in transverse tests and the greater difficulty of obtaining homogeneous, fine-grained structures by heat treatment. His ideas regarding the mechanism of inclusions formation and his distinction between "accidental" and "emulsified" inclusions seem rather vague and inaccurate.

Haigh,[59] from practical and research experience, supports the view that slag inclusions tend to promote fatigue. From a theoretical analysis he concludes that the most important effect is due to the different elastic constants of metal and slag. Any applied load will produce concentrations of stress at and near the boundary zones between the slag and metal, no matter whether such zones are initially stressed or unstressed.

Sommer and Rapatz,[60] from examinations of some steel samples showing woody fractures, found hair cracks and a few flakes, apparently associated with numerous non-metallic inclusions, and concluded that the inclusions were the principal cause of these flakes and hair-cracks.

Clayton, Foley and Laney,[61] in a discussion of flakes and woody fractures in forgings, attributed the effect mainly to effects of overheating on segregated areas in the steel preparatory to forging, and indicated their belief that discontinuities caused by inclusions were not usually responsible.

Rawdon,[62] in a paper on the same subject, gave considerable evidence to indicate that thin cracks or discontinuities originated in the ingot before forging and caused flaky fractures, or cracks which in a large percentage of cases were shown to be related to slag inclusions.

Howard,[63] in a discussion of transverse fissures in rails, concludes that fatigue failures caused by excessive wheel loads and severe service conditions in general, rather than defects in the steel resulting from segregation or severe mechanical and thermal treatment, were essential causes of these fissures. Many of the contributors to the discussion were of the opposite opinion, however. Longitudinal fissures and woody fractures in transverse tests could be definitely traced to slag segregation in many cases, but although several workers believed that transverse fissures were often a result of similar defects, they were apparently not able to establish the connection very definitely.

Priestly,[64] in a paper on oxides and sulphides in high-grade armor-plate steels, etc., attributes important effects to inclusions. He gives data from three heats, in which the drop in elongation and reduction of area from longitudinal to transverse tests was proportional to the degree of "dirtiness" as indicated by sulphur contents and appearance of microsections. The worst steel was from an acid open-hearth, the next from a basic electric furnace not very carefully operated, and the best steel from a duplex basic open-hearth, basic electric furnace process, with no additions of aluminum or other deoxidizers made to the metal just before tapping or in the ladle. The transverse test pieces from the dirtier steels gave laminated or "woody" fractures. He states that "gun forgings and other ordnance material, where transverse tests are required, have never been successfully made from basic open-hearth steel." Instances of inclusions being associated with "flakes" in various steels were mentioned in the discussion of this paper.

[59] Haigh, B. P., Slag Inclusions in Relation to Fatigue. *Transactions Faraday Society*, Vol. 20 (1924–1925) pages 153–158.

[60] Sommer, F., & Rapatz, F., Beitrag zur Kenntnis des Schieferbruches und der Flockenbildung im Stahl. *Stahl und Eisen*, Vol. 42 (1922), pages 1708–1712.

[61] Clayton, C. Y., Foley, F. B., & Laney, F. B., Flaky and Woody Fractures in Nickel Steel Gun Forgings. *Transactions American Institute of Mining & Metallurgical Engineers*, Vol. 62 (1920), pages 211–225.

[62] Rawdon, H. S., Microstructural Features of Flaky Steel. *Transactions American Institute of Mining & Metallurgical Engineers*, Vol. 62 (1920), pages 246–286.

[63] Howard, J. E., Transverse Fissures in Steel Rails. *Transactions American Institute of Mining & Metallurgical Engineers*, Vol. 58 (1918), pages 597–649.

[64] Priestly, M. J., Effect of Sulphur and Oxides in Ordnance Steel. *Transactions American Institute of Mining & Metallurgical Engineers*, Vol. 67 (1922), pages 317–340.

Cain[65] added various impurities to pure iron melts and bent forged bars from these back and forth over an anvil during cooling from 1100–500°, to measure the tendency toward red-shortness. Sulphur caused red-shortness when above 0.01% but with sulphur contents below this limit, oxygen even up to 0.2% did not cause red-shortness. Manganese, when present up to three times the sulphur percentage, prevented red-shortness, and copper seemed to have a similar tendency.

Merica and Waltenberg[66] showed that nickel sulphide inclusions in nickel occurred as grain boundary envelopes and caused red shortness in the same way as FeS inclusions in iron. Manganese additions changed the inclusions to rows of separate globules around the grains (presumably soluble in liquid but insoluble in solid state) and improved the malleability. Magnesium additions formed tiny MgS inclusions apparently crystallized in hexagonal forms, scattered irregularly through the metal (insoluble in both liquid and solid states) and completely restored the malleability characteristic of pure nickel.

Burgess and Woodward[67] characterize zirconium as a scavenger like aluminum and titanium. When not removed in the slag, it remains in the steel as square, bright yellow inclusions, small enough to be seen clearly only with magnifications above 500. These inclusions roll out into thin plate-like streaks, and if segregated may be detrimental, especially in armor-plate.

Feild[68] gives a large number of rather circumstantial but also fairly convincing data to indicate the reactions between zirconium and oxygen, nitrogen and sulphur in steels. Relative losses of silicon and zirconium, when added in the form of silicon-zirconium alloy, indicated that zirconium reacted with dissolved FeO more rapidly than silicon. In a molten alloy containing aluminum, zirconium, titanium, silicon and iron, the relative rates of elimination under an oxidizing slag were in the order named, the rate for zirconium being close to that for aluminum, that for titanium being close to that for silicon. Zirconium seemed to combine with much of the nitrogen in solution to form lemon-yellow cubic crystals of a nitride which was apparently insoluble in liquid steel, and was partly eliminated before the metal was poured into molds. Zirconium also formed sulphide inclusions which from their irregular distribution were probably precipitated in the liquid state. Zirconium seemed to be even more effective than manganese in preventing the red-shortness caused by FeS inclusions.

Feild[69] and several other observers have observed that in practice it seems to require from 2 to 3 times the theoretical amount of manganese necessary to combine with all the sulphur present as MnS, to remove the tendency toward red-shortness caused by sulphur present as FeS inclusions.

Lucas[70] examined pieces of Armco iron which has been subjected to alternating stresses until small cracks began to open at the surface. Photographs at 2000–3500 diameters taken along the course of the cracks strongly suggest the conclusion that the tiny inclusions present served as "stepping stones" for the cracks to progress through the metal.

Evans[71] has shown that variations in oxygen distribution is

[65] Cain, J. R., Influence of Sulfur, Oxygen, Copper and Manganese on the Red-shortness of Iron. *Transactions American Electrochemical Society*, Vol 46 (1924), pages 133–147.

[66] Merica, P. D., & Waltenberg, R. G., The Malleability of Nickel. *Transactions American Institute of Mining & Metallurgical Engineers*, Vol. 71 (1925), pages 709–719.

[67] Burgess, G. K., & Woodward, R. W., Manufacture and Properties of Steel Plates Containing Zirconium and Other Elements. *U. S. Bureau Standards Technical Paper* No. 207 (1922).

[68] Feild, A. L., Some Effects of Zirconium in Steel. *Transactions American Society of Mining & Metallurgical Engineers*, Vol. 69 (1923), pages 848–894.

[69] See also Levy, D. M., A Study of the Manganese Sulphides and Silicates in Iron and Steel. *Iron & Steel Institute, Carnegie Scholarship Memoirs*, Vol. 3 (1911), pages 260–319.

[70] Lucas, F. F., Observations on the Microstructure of the Path of Fatigue Failure in a Specimen of Armco Iron. *Transactions American Society for Steel Treating*, Vol. 11 (1927), pages 531–550.

[71] Evans, U. R., Oxygen Distribution as a Factor in the Corrosion of Metals. *Industrial & Engineering Chemistry*, Vol. 17 (1925), pages 363–372; Evans, U. R., Corrosion at Riveted Joints. *Engineering*, Vol. 124 (1927), pages 179–180; Evans, U. R., The Corrosion of Metals at Joints and Crevices. *Journal Royal Society of Arts*, Vol. 75 (1927), pages 544–567.

often a factor in corrosion of iron and other metals. Any area to which less oxygen is supplied by diffusion becomes anodic to the rest of the metal. This effect frequently leads to excessive corrosion at joints, cracks or narrow crevices in metals. Inclusions at or near exposed surfaces in steel probably have a similar effect.

Smithells[72] gives a general discussion of such effects in a chapter of his book on impurities in metals. The total iron lost due to increased corrosion caused by inclusions in this manner will be negligible in nearly all cases, but the corrosion takes the very worst possible form, i. e., that of pitting. In certain cases, such as those in which the steel is exposed simultaneously to fatigue stresses and corrosion, this tendency to non-uniform corrosion might be quite serious. Such conditions have been investigated by McAdam[73] in his work on corrosion-fatigue of metals.

In general, it is quite obvious that our knowledge of the effects of inclusions on physical properties is quite vague and ill-defined. In fact such a state of affairs is only to be expected, considering the tendency of these impurities to give non-specific or haphazard, rather than specific and definite effects, as discussed in the following section. Bessemer steel is usually considered less reliable for some purposes than open-hearth and electric furnace steels, and the greater variation in cleanliness in the former is probably one of the chief causes of this difference. The higher nitrogen content of Bessemer metal may also be of importance here. Inclusions or dissolved gases may also have a sort of "catalytic" effect on structure by influencing the mode of crystallization from the molten state, etc. The existence and effects of a truly colloidal suspension of particles too small to be detected by known methods still remains essentially an unsolved mystery. Some of these factors will have to be investigated before we shall know whether or not that mysterious quality known as "body," often spoken of in connection with certain high-grade products, such as crucible tool steels, is a myth or a reality.

In the so-called "free-cutting" Bessemer or open-hearth screw stock, a lowered toughness is deliberately produced in order to make better working properties. The higher content of sulphide particles is supposed to lubricate the cutting tools and make the metal chips break off more easily. In many such cases, the steel is used for purposes such that any possible effect of inclusions cannot affect its service value. In nearly all massive construction involving a large factor of safety in design, the effects of inclusions are perhaps entirely negligible in most cases. But the modern tendency is in most cases toward the reduction in weight, excess strength and margin of safety, and the introduction of complex stresses, etc. This change can hardly do anything else but make cleanliness, fatigue resistance and reliability more and more important in steel making.

XVI. Effects of Various Types of Impurities Found in Steels and Their Relation to Phase Diagrams and Solubilities

To form a balanced judgment of the practical effects of any one of the impurities found in steel, it is necessary to consider at least two factors:

(1) What are the specific effects of the impurity* on the various properties of the metal?

(2) What degree of variation from the normal effect is likely to occur, and what are the probabilities of various degrees of departure from the normal?

The laboratory metallurgist is likely to be chiefly interested in the first factor, since it can be more or less accurately determined by laboratory measurement, and usually can be neatly expressed in terms of phase diagrams, curves and equations. The producer or the user of steels on a large scale, however, is likely to be even more interested in the second factor, which is almost impossible to express, except in the form of long time service records, probability curves, percentage rejection figures, etc. If, for example, all the discussion which has been stirred up over "dirty steel" was based on a specific effect of 0.05% or less of non-metallic particles, a series of laboratory tests could be made and the whole problem very likely dismissed as of little practical importance. Actually, of all the various impurities found in steel, the particles are the most likely to be non-uniformly distributed and to produce effects, most of which are entirely unpredictable, except on the basis of probability curves based on dozens, hundreds or thousands of inspections, physical measurements or service data.

A qualitative idea of these differences may perhaps be obtained from the following classification of the impurities occurring in steels, based upon the phase diagrams for the various binary systems involved:

Class 1. Elements which have a fairly large range of solubility in iron in both the liquid and solid states.

Class 2. Substances soluble in iron in the liquid state, but with a much smaller solubility in the solid state.

Class 3. Substances which are more or less soluble in liquid iron, but almost completely insoluble in the solid metal.

Class 4. Substances which form as a suspension by precipitation from the liquid iron solution and which are nearly insoluble in both liquid and solid iron.

The common impurities of Class 1 are silicon, manganese, nickel, chromium, vanadium, etc. Fig. 23 shows, as an example, the equilibrium diagram for the silicon–iron system. In this case the solid solution range is limited, but it extends well beyond the range of commercial steels. The other elements mentioned all form continuous series of solid solutions over and beyond the range likely to be encountered in steels. When mixtures of this type freeze, there is never any large difference in composition between the solid and liquid portions, and in small masses of metal the only non-uniformity will be the so-called "dendritic segregation" in which there is a small periodic variation in composition over distances separating the cores and fillings of the dendrite branches, which distances are ordinarily less than a millimeter.

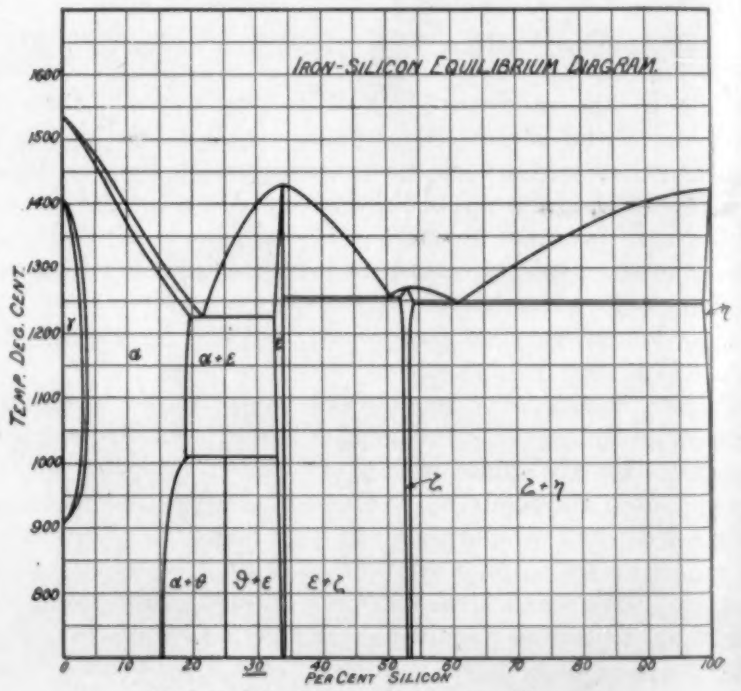


Fig. 23—Iron-Silicon Equilibrium Diagram

In large ingots the Class 1 impurities may be segregated slightly with respect to larger portions of metal. In "rimmed" ingots, the gases evolved during solidification form upward-sweeping currents which "wipe" the purer metal freezing first on to the surface of metal growing inward from the ingot walls, and sweep away most of the less pure liquid portion to

[72] Smithells, C. J., Impurities in Metals. John Wiley & Sons. (1929), pages 131–152.

[73] McAdam, O. J., Jr., Stress-Strain-Cycle Relationship and Corrosion Fatigue of Metals. *Proceedings, American Society for Testing Materials*, Vol. 26, Part II (1926), pages 224–254.

* Impurities are here considered in the broad sense, as any foreign element other than iron present in the metal.

freeze later in the core portion of the ingot. As a result, the whole rim portion of the ingot will be lower in impurities than the core. For the Class 1 impurities, the resultant differences are small, simply because with these there is never much difference between the liquid and solid compositions which are in equilibrium with each other. In killed ingots, in which the metal is relatively quiet during freezing, there is usually in the lower central portion a zone of negative segregation which may be caused by the purer and denser crystallites falling toward the bottom during the slow freezing of the whole central zone of the ingot. Here again, however, the Class 1 impurities should be least segregated.

The common impurities of Class 2 are carbon and phosphorus. They are soluble in the solid state in the amounts ordinarily present in steels, but compared to the elements of Class 1, there is a relatively large difference in composition between the liquid and solid portions present together during freezing. Fig. 24 shows part of the phase diagram for the iron–phosphorous system given by Haughton.[74]

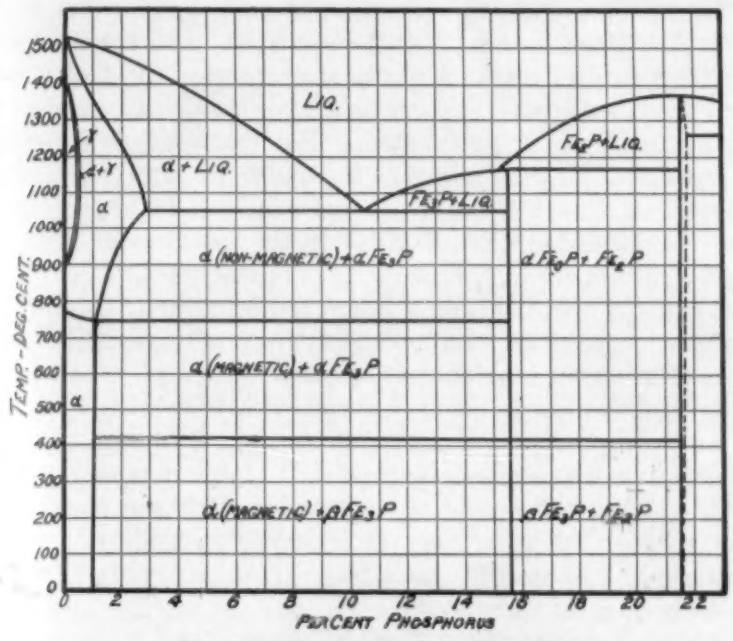


Fig. 24.—The System Iron–Phosphorus

Class 3 includes such substances as FeS, MnS and FeO, which are soluble in the liquid state, but nearly insoluble in the solid state, as illustrated by the Fe-FeS diagram of Fig. 18. In this case the solid separating first is practically pure iron, and the last liquid to freeze in small areas between the crystals contains 85% or more of FeS. In this way, very large variations in composition over small distances in the metal may result, which is not true of the impurities of Classes 1 and 2.

All the impurities of Classes 1, 2 and 3 are in solution in the liquid metal, and they can segregate only during the freezing period. Any one cubic centimeter of iron will then average out to give nearly the same contents of these impurities as any other such portion, unless, as is true in large ingots, some action occurs which tends to separate the solid and liquid portions present during freezing. Where such an action occurs, the resultant differences in composition should be much greater for the impurities of Classes 2 and 3 than for those of Class 1. This conclusion is very well supported by the results obtained by the Committee on Heterogeneity of Steel Ingots of the Iron and Steel Institute.[75] A large number of commercial ingots of various sizes were sectioned vertically along the axis and in each one a large number of samples for analyses were drilled from the cut face. The results showed surprising amounts of segregation, effected during the slow freezing of these large masses of steel, varying in weight from 3/4 ton to 172 tons. Table 1 summarizes most of the data in the form of segregation ratios for the various impurities in each ingot, these being simply the ratios of the maximum to the minimum values for a given impurity in a given ingot section. In cases where the maximum values occurred in the sink heads or close to the bottom of the pipe, in steel which would ordinarily be cropped before rolling, these values were not used but the next highest values taken. In any one ingot, the ratios usually increase in the order; Ni, Cr, Mn, Si, C, P, S. Comparing the values for carbon, with those for manganese and silicon, however, we find a much greater average increase than anywhere else in the series, which tends to justify the distinction between Class 1 and Classes 2 and 3, impurities given above. In all the killed ingots, in which the mechanism of segregation was presumably the same, the ratios increase, though somewhat irregularly, with the ingot weights. This is to be expected, of course, since with increased weight of metal, the period of freezing becomes longer and there is better opportunity for the separation of solid and liquid portions in the center zone of the ingot.

The Class 4 impurities in steel include SiO_2, MnO, Al_2O_3, TiO_2, V_2O_3, etc., and various mixtures of these oxides. FeO, when present in any of these mixtures, or in pure iron in excess of 0.92% is also precipitated from solution in the liquid iron and then also falls into this class. Those substances which are ordinarily classed as non-metallic inclusions obviously include all the impurities in Classes 3 and 4. Certain less common nitrides and sulphides may also fall into Class 4.

These substances are all formed by precipitation from the liquid solution and are already present as a separate phase of suspended particles before the steel solidifies. They are all less dense than liquid iron and tend to rise out of the metal while it remains liquid. Comparatively few data on the modes of segregation of such particles are available, and it is not possible to predict anything about them from the data

[74] Haughton, J. L., The Constitution of Alloys of Iron and Phosphorus. *Journal Iron & Steel Institute*, Vol. 115, No. 1 (1926), pages 417–434.

[75] Committee on the Heterogeneity of Steel Ingots, *Iron & Steel Institute*. First Report, 1926 (No. 1), Vol. 113, page 39. Second Report, 1928 (No. I), Vol. 117, page 401. Third Report, May 1929, Advance Copy.

Table 1—Segregation Ratios in Steel Ingots

No.	Wt. of Ingot Tons	Ni	Cr	Mn	Si	C	P	S	Cu	Mo	Furnace Used	Remarks
17	3/4	1.04	..	..	..	1.18	1.57	1.50	..	..	A. O. H.	Killed steel chill mold
32	1 1/4	..	..	1.08	1.24	1.24	1.23	1.32	..	..	A. O. H.	Killed steel bottom cast
19	2 1/4	1.03	1.06	..	..	1.26	..	..	..	..	Electric	Killed steel chill mold
20	2 1/4	1.03	1.05	..	..	1.36	..	..	..	..	Electric	Killed steel chill mold
4	2 3/4	..	..	1.07	1.09	1.34	1.28	1.31	..	..	A. O. H.	Killed steel chill mold
18	2 5/8	1.03	..	..	..	1.14	1.45	1.92	..	..	A. O. H.	Killed steel chill mold
7	3 1/4	..	..	1.21	..	1.60	2.19	2.30	..	..	B. O. H.	Killed steel chill mold
8	8	..	..	1.11	..	1.43	1.26	1.81	..	..	B. O. H.	Killed steel chill mold
9	8 1/4	..	..	..	..	1.56	1.78	3.13	..	..	B. O. H.	Killed steel loam mold
10	10 1/2	..	..	1.16	1.15	1.73	1.33	3.87	..	..	Electric	Killed steel chill mold
11	20	..	..	1.06	1.10	1.47	1.67	1.73	..	..	A. O. H.	Killed steel chill mold
12	25	..	..	1.17	1.16	1.59	1.92	2.43	..	..	A. O. H.	Killed steel chill mold
21	49	1.07	1.13	1.15	1.11	1.71	2.00	2.14	..	..	A. O. H.	Killed steel chill mold
22	50	1.11	..	1.13	1.23	1.50	1.60	1.83	1.38	..	A. O. H.	Killed steel chill mold
14	64	..	..	1.18	1.25	1.66	2.04	2.12	..	..	A. O. H.	Killed steel chill mold
15	110	..	..	1.25	1.17	3.07	2.52	3.48	..	..	A. O. H.	Killed steel chill mold
23	119	1.05	1.20	1.11	..	1.52	2.82	1.76	..	1.38	A. O. H.	Killed steel chill mold
16	172	..	..	1.27	1.43	3.14	4.0	4.53	..	..	A. O. H.	Killed steel chill mold
24	3	..	..	1.07	..	2.73	3.20	5.43	..	..	B. O. H.	Rimmed steel chill mold
25	6 3/4	..	..	1.09	..	1.80	2.08	3.10	..	..	A. O. H.	Semi-killed Plate steel
26	7 3/4	..	..	1.11	..	2.27	2.62	3.22	..	..	A. O. H.	Semi-killed Plate steel
27	6 3/4	..	..	1.11	..	2.40	2.42	2.43	..	..	A. O. H.	Semi-killed Plate steel
28	8	..	..	1.18	..	1.93	1.93	2.57	..	..	A. O. H.	Semi-killed Plate steel
29	3 1/4	..	..	1.11	..	1.60	1.79	1.69	.	..	B. O. H.	Free-cutting steel
30	7 3/4	..	..	1.09	1.21	1.60	1.64	1.70	.	..	A. O. H.	Plate steel

on the segregation of the impurities of Classes 2 and 3. The latter separate from solution during freezing, whereas those of Class 4 are already suspended in the liquid iron before it starts to freeze; it is therefore only reasonable to expect that the two classes of impurities would be distributed differently in the solidified ingots. Moreover, two kinds of non-metallic particles which differed widely in average size, density, melting points, etc., might also differ widely in degree and manner of segregation.

Dickenson[52] gives some data on the segregation of impurities in a few ingots sectioned vertically and includes results for silicate contents extracted by dilute nitric acid. Fig. 25

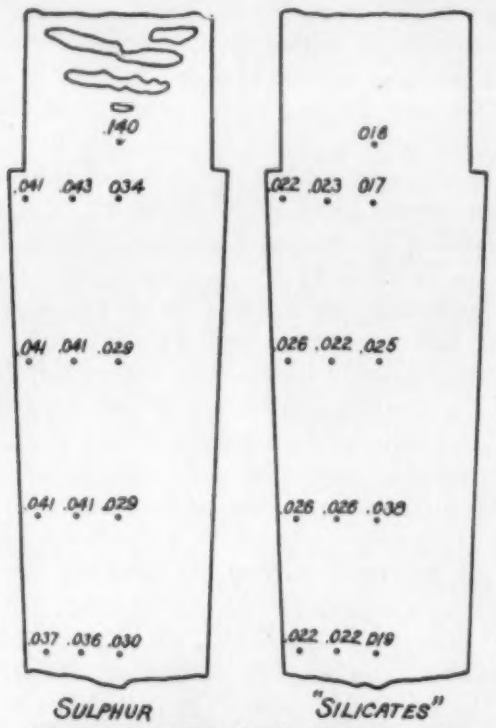


Fig. 25—Data Showing Segregation of Non-metallic Inclusions and Sulphur in the Same Ingot (Dickenson, *Journal Iron & Steel Institute*, Vol. 113 (1926). page 177)

shows the results for sulphur and for silicates in one killed ingot. The lower central zone where the Class 3 impurities were lowest, contained the largest amounts of silicate inclusion in every case. Dickenson explained this effect as perhaps caused by falling crystallites in the central zone carrying the silicate particles down with themselves toward the bottom of the ingot. Particles of Class 4 impurities would be present along with the purer crystallites forming at a stage in the freezing process when the greater portion of the Class 3 impurities were still dissolved in the liquid phase. The segregation ratios for silicates varied from about 2.3 to 11.2. They were in general much higher than the ratios for other impurities, which in these particular ingots were rather low as compared to corresponding values in Table 1. It is important to remember that other types of inclusions might not segregate in the same manner as those in the ingots examined by Dickenson. A great deal of work on the subject remains to be done. Important results might be obtained by sectioning a number of rather large ingots in each of which nearly all the inclusions were of certain type, such as large manganese-iron-silicate particles; glassy, high-silicon inclusions; very small alumina or alumina-silica particles, etc.

Considering the more localized segregation usually evident only in micro-structures, the essential distinction comes between Classes 1 and 2, which may be termed "alloying impurities" and Classes 3 and 4, which include those substances called "non-metallic inclusions." The "alloying impurities" are either in solution in the solid steel or else form carbides which are similar enough in properties to the solid solution phase to strengthen the steel and form for all practical purposes a homogeneous material.

The "inclusions" are sulphides, oxides or silicates which in the solid metal are present as a separate phase of irregularly scattered particles very different in physical properties from the metal matrix. These particles are more or less equivalent to actual discontinuities in the metal, such as blow-holes, hair-cracks, etc. The individual particles are ordinarily much below 15–20 microns in size, but are very commonly grouped together in irregular patches in which the concentration of particles may be extremely large compared to the immediately adjoining metal. The data on ingot segregation discussed briefly above showed that with respect to what we might call "megascopic" or large-scale segregation (measured in centimeter distances) the impurities of Classes 2, 3 and 4 gave high ratios compared to Class 1, although the ratios for Class 4 were markedly higher than those of Classes 2 and 3. On the other hand, "microscopic" irregularities are comparatively small in Classes 1 and 2, but may be very large in Classes 3 and 4, containing the non-metallic inclusions.

Much more might be written on the general subject of segregation in steel, but the discussion above is given chiefly to form a view point that will help indicate the sort of effects to be expected from the presence of non-metallic inclusions in steel. Class 1 and Class 2 impurities have marked and definite specific effects on physical properties, most of which have been measured and serve as a basis for closely estimating the properties of a given steel. For example, if a certain percentage of nickel is added to the metal, we may confidently expect that this will be nearly uniformly distributed (maximum variation less than 5–10%) in the metal even in large ingots. Moreover, it will be atomically dispersed in the space lattice of the iron (with only minor periodic variations due to dendritic segregation) and will always exert its definite maximum effect on the inherent properties of the metal. Carbon is either atomically dispersed or forms a carbide with 14 times its own weight of iron and this carbide is uniformly distributed in a fine grained aggregate. In large masses of metal it will vary in concentration as much as 100% or more, but even these differences may be given proper allowance by calculation, and in any small piece of the steel its effect is perfectly definite and specific.

The non-metallic impurities of Classes 3 and 4 are almost never dispersed in steel in a manner calculated to give much specific effect on its properties. Their total concentration is nearly always below 0.15% and of this all but a small percentage is present in particles large enough to contain in each one several thousands of molecules. With such extremely ineffective distribution, it is quite unreasonable to expect that inclusions would have much of measurable specific effects on tensile strength, elastic properties, hardness, crystal structure, etc., such as are caused by the impurities of Classes 1 and 2. Inclusions are occasionally found sufficiently concentrated in some cross-sections of a tensile test specimen to give a very marked lowering of strength or ductility. But such an effect is "accidental" and haphazard in nature and usually entirely unpredictable, except in terms of probability, percentage failures, etc. It would be quite unsafe to say that inclusions have no specific effects of any importance on commercial steels. A few such effects are indicated, usually coincident with very finely divided and dispersed inclusions. As discussed in Section II, submicroscopic FeO inclusions may be precipitated in solid iron to cause abnormal carburized structures, and aging effects after cold working. Alumina inclusions in wire rod cause increased abrasion of the dies and often cause poor surfaces on the wire. Iron sulphide inclusions are more or less specific in their tendency to cause red shortness, etc.

But these specific effects are probably less important than the occasional service failures caused by a segregation of inclusions in a highly stressed piece of steel. It is the haphazard and unpredictable nature of these failures that naturally make them particularly dangerous and make it so hard to accurately estimate the importance of a certain average content of inclusions in a lot of steel. A bridge designer may

use a steel of lower carbon or nickel content by simply varying the design or increasing the weight of his sections. But even with reasonably clean steel a failure might conceivably occur in a bridge member, perhaps by a segregation of inclusions, high stresses and certain conditions of vibration or stress-reversal happening to occur all at the same point. The probability of such a concurrence of several conditions, all of them necessary to cause a service failure, will probably not be a simple function of any one factor such as the average inclusion-content in the steel. A steel producer or user who happens to have little trouble from service failures caused by dirty steel and who considers the lack of measurable specific effects and the difficulty of estimating the probability of dangerous segregation is usually tempted to dismiss the whole problem as of no importance. Also, since some inclusions are distributed through all commercial steels, the mere occurrence of a few particles adjacent to the zone of failure in a broken member often leads to a diagnosis of "dirty steel" in cases where poor design or heat treatment have actually caused the inherent limitations of the metal to be exceeded.

To sum up the above discussion we may say that the phase relations between iron and the classes of impurities called non-metallic inclusions indicate plainly that these impurities must be largely haphazard and irregular in their most important effects on the metal. The problem becomes difficult to solve; it is quite easy to overestimate the importance of these irregular effects, but quite as easy to underestimate their importance. Hence the danger of dismissing the whole problem without thorough investigation. Presumably, a service failure connected with dirty steel is not the result of any one single cause, but originates from the coincidence of a segregate of inclusions with stress concentrations caused by certain conditions of cold or hot working, defective design or machining or uneven cooling or heating. The temptation is to over-simplify the problem and look for one single cause to be the villain in the case.

New Specifications for Copper-Brass Alloys

Announcement is made by the American Society for Testing Materials of the acceptance as tentative, through the Society's Committee on Standards, of new Specifications for Copper–Base Alloys in Ingot Form for Sand Castings. These specifications represent a complete realignment of the specifications covering copper base alloy ingot metal, and the direct outgrowth of a survey, during the past few years, by a special committee of the many alloys in this field, in an endeavor to develop specifications that would greatly simplify the present conditions. This survey was prompted by the desirability of having specifications available for use as a basis for price quotations in trade papers, and to improve the existing condition that definitions of alloys in ingot form, upon which price quotations in the trade papers are based, are exceedingly lax. The special committee was accordingly organized, consisting of producers, consumers, general interests and trade paper representatives. The committee was assisted through the whole-hearted support of the Non-Ferrous Ingot Metal Institute. Through the membership of the institute information was received concerning the alloys at present in use and the uses to which these alloys are put. More than 600 alloys were reported upon.

At the suggestion of the joint committee the Non-Ferrous Ingot Metal Institute also sponsored a research associate at the Bureau of Standards to study certain of the alloys within each of the classifications, with the object:

1. To provide the industry with more complete information regarding the alloys in use.
2. To be used as a guide in greatly reducing the number of alloys used.
3. To be used as a guide in revision of present A. S. T. M. Specifications.

Based upon the survey, Committee B-5, on Copper and Copper Alloys, Cast and Wrought of the American Society for Testing Materials, completely revised the specifications for brass ingot metal to include a more extended list than in the previous specication and to formulate more practical and workable specifications. The list includes 15 alloys. These it is believed through conscientious effort, education and determination, may be used in place of the more than 600 alloys now in use by the industry. These specifications are published as tentative in order that they may serve until further knowledge is obtained through the work of the research associate, and through experience, after which the specifications will again be reviewed and possibly amplified.

Engineers and mechanics with sporting proclivities, as well as motorboat enthusiasts, will be interested in the information recently given out by the Fredericksen Company, Saginaw, Michigan, that "SABECO" Bearing Metal of its manufacture was employed for the strut bearings of Gar Wood's "Miss America IX" launched at Marysville, Michigan, which defended the Harmsworth Trophy in the International Motorboat races.

"SABECO" is a high-leaded bronze said to border on the oilless type, non-seizing and non-scoring and has been used by the builder, Mr. Wood, for strut bearings in all of his previous winners with very satisfactory results.

William G. Schneider, of the Research Department of the Copper & Brass Research Association presented in an address on "Copper and Health," before the New England Water Works Association, at Atlantic City, N. J., September 25, technical data to show that copper normally taken into the human system is not harmful but, on the contrary, may be beneficial.

The **Material and Equipment Inspection Bureau** at 332 South Michigan Avenue, Chicago, Ill., is a new organization, which renders a professional service in the field of inspection, purchasing and liquidation.

The **Mathieson Alkali Works** are issuing a series of bulletins on the production of cleaner iron, the elimination of losses from defects and shrinkage in non-ferrous castings and other advantages which have been secured through the proper use of Purite as a refining and deoxidizing agent. The following bulletins have already appeared: "Fluxing with Purite," "Purite in Non-Ferrous Metallurgy," "Desulfurizing with Purite," "Refining Iron with Purite" and "Purite in Malleable." These bulletins may be obtained by addressing a request to the Mathieson Alkali Works, 250 Park Ave., New York, N. Y.

The **Electric Steel Founders' Research Group,** 541 Diversey Parkway, Chicago, is distributing a filing folder whose tab reads, "Specifications for Ferrous Castings," in which new specifications may be filed. The latest A. S. T. M. specifications as to composition and physical tests for steel, and cast and malleable iron, are printed on the inside, in concise, summarized form. The back shows photos of the plants in the Research Group. It is an original and useful folder.

Addison Beale Dies Suddenly

Addison H. Beale, president of the A. M. Byers Company, died suddenly in Chicago, October 28th.

Mr. Beale was taken ill in the offices of H. A. Brassert & Co., consulting metallurgical and mechanical engineers, and was taken to the home of his son, Warren Beale, where he died a short time later.

Mr. Beale had been a prominent figure in the steel trade. He was president of the A. M. Byers Company for five years, and previously had been associated with the American Sheet and Tin Plate Company, Eastern Steel Company, Lebanon Iron Company and the Steel and Tube Company of America.

At the time of his death he was also president of the Pennsylvania Industries Company, and was on the boards of directors of the Pittsburgh United Corporation and the Sharon Steel Hoop Company.

He was a member of the Duquesne Club, Oakmont Country Club and the Pittsburgh Field Club.

Pierce D. Schenck

It is with regret that we record the death, on October 15, of Pierce D. Schenck, president of The Duriron Company, Inc. of Dayton, Ohio.

Extrusion of BISMUTH WIRE

By J. G. Thompson†

I. Introduction

Metallic bismuth possesses a number of unusual properties which have been discussed in some detail in a recent publication.[1] Some of these unusual properties, for example, the high thermal e. m. f. (about 80μv per ° C. against silver), the high electrical resistance (106 microhm-centimeters at 0° C.) and the increase in resistivity of bismuth on exposure to a magnetic field, have created some demand for bismuth wire to be used in thermocouples or thermopiles, in coils for the determination of the strength of magnetic fields, and in other cases where the peculiar properties of bismuth could be used to advantage. Experiments on the production of bismuth wire were undertaken as part of an investigation of the uses of bismuth, conducted under the Research Associate plan and supported by the Cerro de Pasco Copper Corporation.

II. History

Bismuth has been prepared in the form of wire, or in thin flat strips, in several ways. Coblentz[2] prepared thin strips by dropping molten bismuth from a height of about one meter onto an inclined plate. From the resulting strips pieces 0.02 to 0.04 mm. in thickness were selected for the construction of sensitive thermopiles. Pfund[3] used a method which consisted in hurling the molten bismuth with considerable force against the plate to produce finer spatters. Such strips obviously are difficult to reproduce and a strip of any appreciable length will not have a uniform cross section throughout its length.

Single crystal rods or wires, sometimes as fine as 0.1 mm. diameter, have been prepared by Von Gomperz[4] and by Obreimov and Shubnikov.[5] The former used the Czochralski method of steadily raising a rod from contact with a bath of the molten metal; the latter used a modification of Tammann's method in which crystallization is started at the apex of a tapered glass tube containing the molten metal. Von Gomperz reports considerable ductility of some of his wires, depending on conditions of operation, but the wires were not uniform in cross section throughout their length.

Taylor[6] prepared wires of a number of metals by filling a glass tube with a metal, heating the tube until it was soft and the metal molten, then drawing the tube to the desired size. The glass tube can be removed by etching or can be left to protect the wire. Wire made by the Taylor process has been available commercially in lengths of a few feet but the variations in the diameter of the wire necessitate separate calibration of each piece. This interferes with the interchanging of wires or coils in apparatus. Taylor states that bismuth wire is soft and pliable and suggests its use in resistance pyrometers, thermocouples, galvanometer suspensions and hair lines for microscopes.

Extruded bismuth wire, in sizes down to 0.001 inch diameter, has been stated to be available commercially but details of its methods of manufacture are not available. Stockbarger[7] describes an extrusion press for the production of bismuth wire employing a modification of Bridgman's[8] press for the extrusion of antimony and tellurium. Stockbarger describes the production of wire 0.004 inch in diameter, from both solid slugs and powdered bismuth at temperatures of about 25° C. and about 100° C. Less pressure was required for extrusion at the higher temperatures and the properties of the wire were said to depend on the temperature. The wire was "quite pliable and possessed good tensile strength but broke readily in compression."

* Published with the approval of the Director of the Bureau of Standards.
† Research Associate for the Cerro de Pasco Copper Corporation.

III. Experimental

Commercial bismuth was used in all these experiments. The purity of this commercial product is shown by the following analysis:

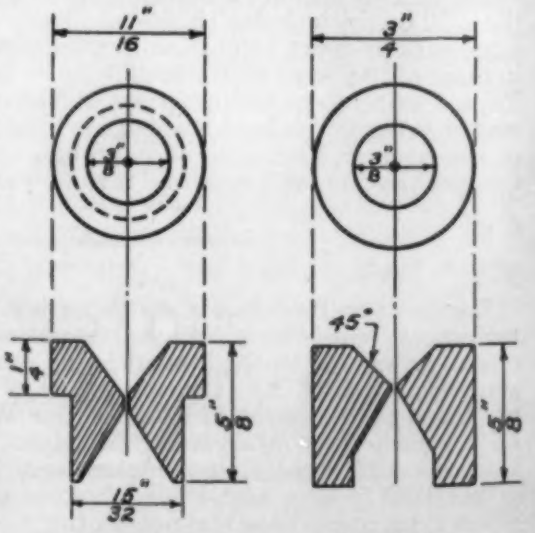
Bi	99.99%
Ag	0.0007
Cu	0.00065
Fe	0.001
Pb, Zn and Sb	nil
As and Te	negative Bettendorf test.

The freezing point of this metal was found to be 271.3° C.** It is interesting to note that the freezing point of this unusually pure metal is slightly higher (0.3° C.) than the generally accepted melting (or freezing) point for "pure" bismuth.

Some preliminary experiments were performed with a small extrusion press which had been used previously for the extrusion of lead wire 0.005 inch in diameter. Although there was no difficulty in making lead wire with this die, it could not be used for bismuth wire. Using the maximum pressure which the die would withstand, the bismuth wire was extruded only for an inch or two. When dies with larger orifices 0.025 and 0.040 inch, were used pieces of wire up to about 8 ft. in length were produced. These carbon steel dies, of the "old" design shown in Fig. 1, were subject to breakage, which occurred usually in the plane of the orifice and of the right angled shoulder. Dies were constructed of a chromium steel which contained 14% chromium. The strength of these dies was satisfactory but the wire produced was in short pieces and was rough and brittle. Additional polishing of the die and orifice did not improve results to any appreciable extent, in fact it appeared to be impossible to produce and maintain, in this steel, a surface smooth enough to produce good wire.

As a result of these experiments it was decided to return to dies of hardened, plain carbon steel. This material is more easily worked than are alloy steels, and can be readily polished to the necessary degree. A new press was built to accommodate larger, stronger dies of the "new design" shown in Fig. 1. This press, illustrated in Fig. 2, consists

** Thanks are due to Dr. H. T. Wensel of the Heat Division of the Bureau of Standards for this determination of the melting point of bismuth. The pronounced tendency of molten bismuth to supercool caused considerable difficulty in this determination. Unless the molten metal was agitated continually and vigorously, by hammering on the container, the melt would supercool to such an extent that when crystallization finally did occur the latent heat of crystallization was not enough to bring the entire mass up to the true freezing point. However, vigorous hammering on the container prevented supercooling and it is believed that the true value for the freezing point of the material was obtained.



Old design New design

Fig. 1—Dies for Extrusion Press

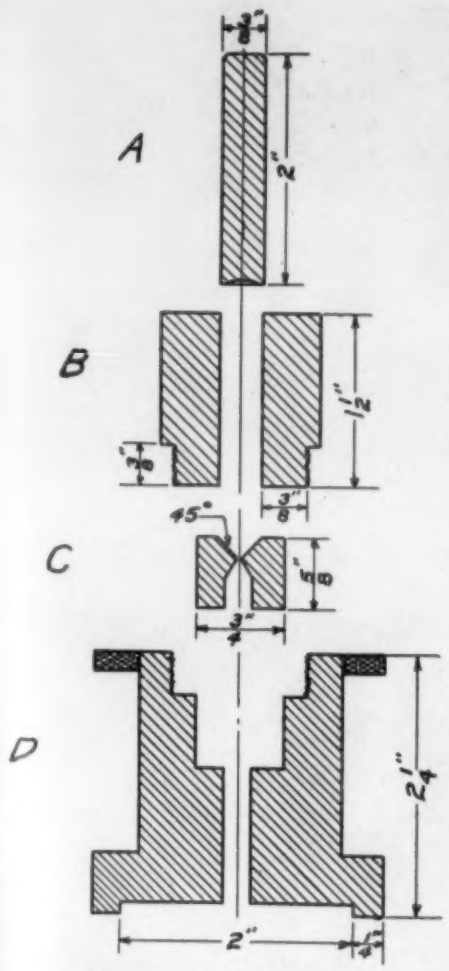


Fig. 2—Extrusion Press for the Production of Bismuth Wire

of a plunger (A), barrel (B), die (C) and base (D). The base was mounted on a 2-inch length of heavy 2-inch steel pipe. A chromium alloy steel was used for the plunger in order to obtain greater strength. The rest of the press and the dies were constructed from a plain carbon steel which contained about 1 % carbon.

The entrance angle for the dies was made 45°, as suggested by Stockbarger.[7] The bottom of the die was drilled out to leave as short an orifice as possible. The dies were shaped, then hardened slightly and the orifice and entrance were highly polished. The die slid easily into the recess in the base, and protruded slightly above the shoulder of this recess so that, when the barrel was screwed into the base, contact was made between the top of the die and the bottom of the barrel. If these two surfaces are lapped it does not require the application of much pressure in assembling to secure a bismuth-tight joint.

The lower portion of the base and the top of the barrel were hexagon shaped to facilitate gripping in assembly or disassembly. The bottom of the base was recessed slightly to fit over the pipe support. The base was fitted with an asbestos collar which formed one end of the recess in which the heating element was placed. The ends of the heating element were anchored to binding posts mounted in the asbestos collar.

To operate the assembled press, a cast slug of bismuth is placed in the barrel above the die, the plunger is inserted in the barrel and pressure is applied. The amount of pressure required depends upon the diameter and length of the orifice and upon the temperature of the die. A convenient way of applying the pressure is by means of an Amsler testing machine, using the arrangement for compression testing and keeping the rate of travel of the cross head low, 0.05 inch per minute or thereabouts. The use of a small pad of cotton waste, slightly oily, on top of the bismuth slug and under the plunger aids materially in preventing sticking of the plunger in the barrel. Unless such a pad is used thin fins of bismuth may be forced up between the plunger and the walls and result in sticking and scoring of the plunger.

Three dies have been used to produce wire 0.012, 0.025 and 0.031 inch in diameter. At room temperature it requires about 7500 lbs. load for the 0.031 inch die and about 8500 lbs. for the 0.012 die. This corresponds roughly to compression stresses of 75,000 and 85,000 lbs./in.^{2} inch on the plunger. At higher temperatures the pressure required is somewhat less than these figures. The effect of the length of the orifice on the performance of the die was illustrated in the case of the 0.012 die. As first constructed, the application of 10,000 lbs., or more, produced extrusion at the rate of about 2 feet per hour. Decreasing the length of the orifice, without changing the diameter, decreased the critical load to 8500 lbs. and resulted in extrusion at the rate of one or two feet per minute. These experiments account for the failure of the first die to function satisfactorily. The length of the orifice was too great.

Wires up to 20 feet in length have been produced. Good results were obtained only when the barrel was charged with a single solid piece of bismuth. Air bubbles trapped in the cast slug and oxide particles or films caused breaks in the wire at the orifice. Attempts to obtain long pieces of wire when the charge consisted of more than one piece of bismuth, were never successful. Stockbarger reported successful operation with a charge of powdered bismuth but in the present investigation we were unable to duplicate this result.

If the length of the orifice is short, roughly the same as the diameter, an increase in the rate of travel of the movable head of the compression machine results in extrusion of wire at an increased rate without developing an increase in pressure. However, if the length of the orifice is great as compared to its diameter, an appreciable amount of energy is required to overcome friction, and an increase in the rate of extrusion can be obtained only by an increase of pressure.

The mechanical properties of the wires were not determined. The wires were strong enough and flexible enough to permit forming in coils 0.125 inch, or larger, in diameter. The flexibility of the wires increases as the diameter decreases although not even the 0.012 wire could be wound on its own diameter. Attempts to cold work the extruded wire were not successful. A piece of 0.04 inch extruded wire was drawn through an 0.0385 inch sapphire die without much breakage but was so embrittled by the operation that it could not be started through an 0.036 die.

The properties of the wire are affected by several factors. An imperfect die produced only short pieces of rough, brittle wire; extrusion at temperatures slightly below 100° C. seemed to produce more flexible wire particularly in the larger diameters, but extrusion at room temperature produced excellent wire from dies of smaller diameter; extrusion at too fast a rate promotes brittleness in the wire but for any given die, particularly with the smaller diameters, considerable variation in the rate is permissible.

IV. Conclusion

Bismuth wire has been produced in single pieces up to 20 feet in length by means of an extrusion press which is described in detail. Three dies with orifices, respectively, 0.012, 0.025 and 0.031 inch in diameter, were used and successful operation was obtained at room temperature and at higher temperatures, up to about 100° C. Long pieces of wire were obtained only when the press was charged with a single, sound piece of bismuth. The pressure necessary for extrusion depends upon the dimensions of the die and upon the temperature. The properties of the wire vary with the diameter and with the conditions of extrusion. In general the wire is flexible enough and has enough tensile strength to be formed in a coil of comparatively small radius but will break if bent too rapidly or at too acute an angle.

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X-Ray Investigation of Metals in the U.S.S.R.

By E. F. Bachmetew*

Radiological research workers in the U.S.S.R. have already published various articles. U. V. Woolf of Moscow formulated the law of diffraction of Roentgen rays at the same time as W.H. and W. L. Bragg. N. E. Uspiensky and S. T. Konobievsky of Moscow reported on the structure of cold-rolled Al, Cu, Pt and Fe at the Moscow Physical Society in February 1930; N.J. Seliakov, of G. V. Kourdiumov, and other Leningrad workers have reported on the structure of steel after various thermal treatments. The object of this article is to give an account of the present state of radiology in its application to the study of metals in the U.S.S.R.

The mighty industrial development of the U.S.S.R. during the last few years has, on the one hand, stimulated the practical application of much theoretical knowledge, and has made the scientific work take into account the requirements of engineering practice, and, on the other hand, has brought forward a number of new theoretical problems. In the field of investigation of metals and alloys all the modern methods including X-ray analysis are being applied. This last, though being novel to many laboratories, is gaining ground owing to its wide applicability and to its powers from the point of view of both theory and experiment.

As up to the last year domestic equipment for X-ray examination of metals in the U.S.S.R. was insufficient, foreign equipment was used. This was chiefly furnished by American, French and German firms. While it is true that the possession of equipment is, sometimes a stimulus to research, it is all the more true that the need for the solution of a scientific problem at the same time leads to the creation of the necessary equipment.

And as far as the scientific thought was keeping pace with the economic reconstruction of the U.S.S.R. it was continually

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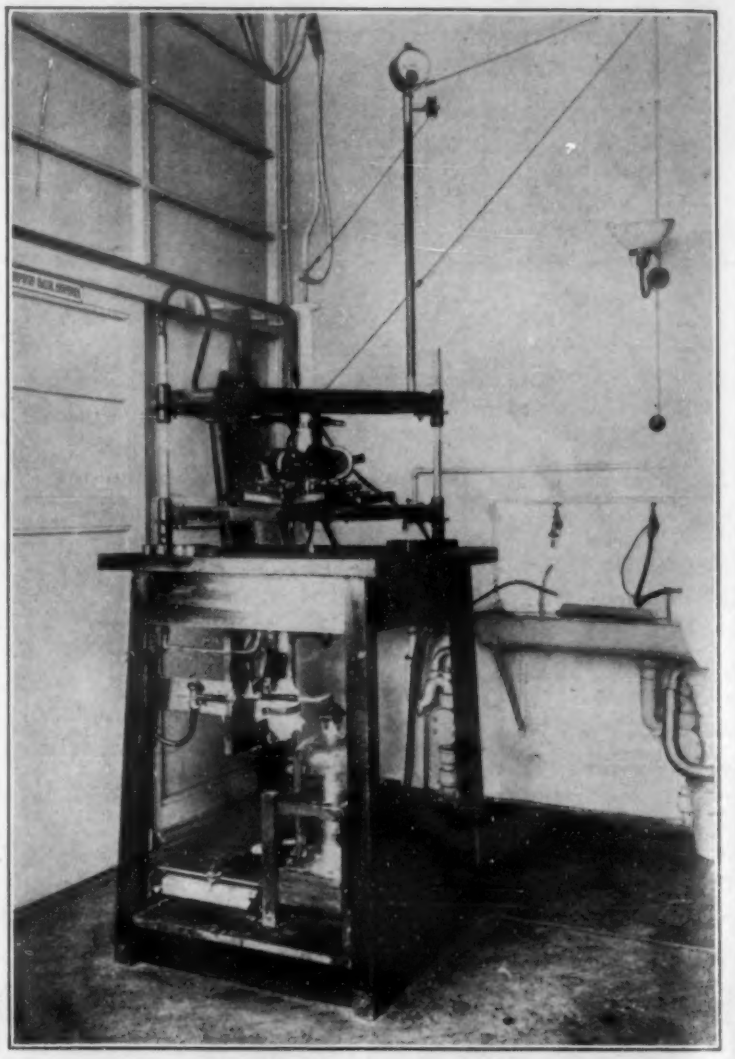

Fig. 2—A Hadding Type X-Ray Equipment for X-Ray Crystal Analysis of Metals in the Radiological Laboratory of the Central Aero-Hydrodynamical Institute, Moscow. All Parts of This Equipment Were Manufactured in the U. S. S. R.

finding new needs for X-ray equipment and apparatus. At present the U.S.S.R. is already producing X-ray apparatus and equipment of several kinds, some of which is shown in the illustrations.

The research work is carried out mainly at the research institutes and partly in the laboratories of educational institutions and manufacturing plants. It is necessary to point out that Russian physicists working with X-rays at the research institutes give considerable attention to problems connected with the study of metals and readily come to work in the laboratories of the manufacturing plants; on the other hand, the engineers working in the shops, and in the research institutes are beginning to use X-ray methods to a great extent, making independent investigations. This results in a close contact between engineers and physicists, insuring a bright future to the new and as yet independent branch of science, the Physics of Metals.

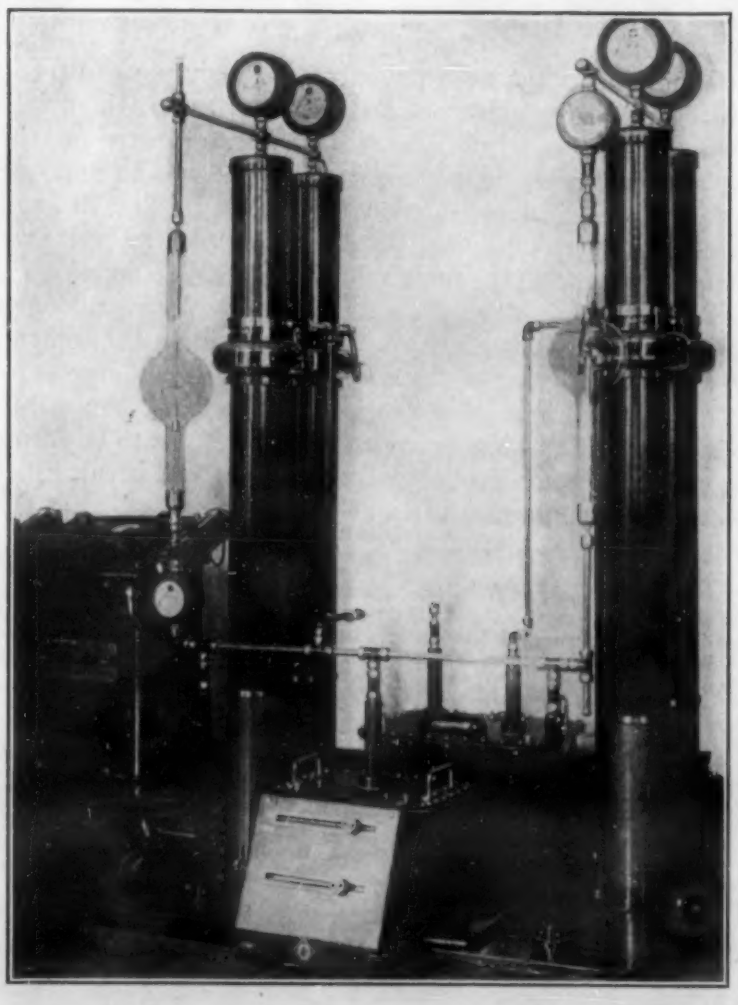

Fig. 1—A 250,000-Volt X-Ray Pulsating Voltage Equipment for Triple Step Design, Manufactured by the State X-Ray Equipment Works, Moscow

S. P.-T. and R. Institute

The State Physico-Technical and Radiological Institute (in Leningrad), where Joffe is working, has a number of laboratories devoted exclusively to the study of metals, the work being carried out under the direction of N. J. Seliakov. Among the problems studied are: thermal treatment of high-carbon and special steels, the problem of martensite, the nature of solid solutions, the plastic properties of metals. As a result of a study of the transformation of a solid solution during the transformation of austenite into martensite there was put forward by Jwensen and Kourdiumov a new scheme to supersede Bain's theory of change of orientation. According to this scheme, which is in agreement with the views held by Scheil the slip planes are considered to be the chief factor. Further work in this direction is being

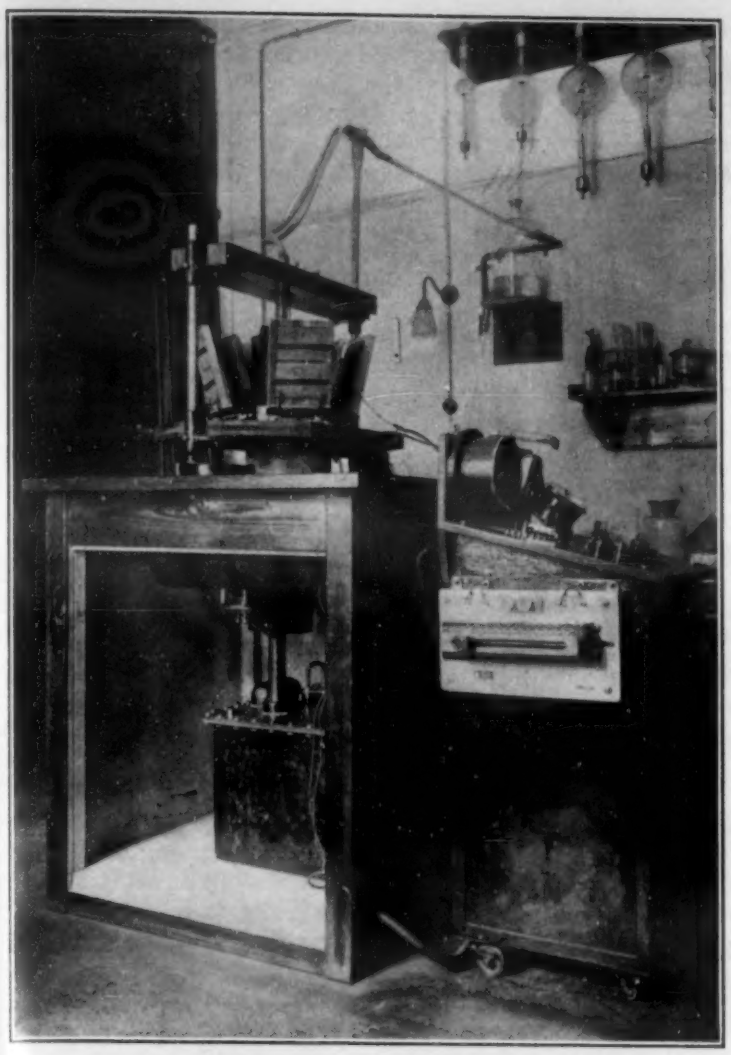

Fig. 3—A Coolidge Type X-Ray Equipment for X-Ray Crystal Analysis of Metals in the Radiological Laboratory of the Central Aero-Hydrodynamical Institute, Moscow. All Parts of This Equipment Were Manufactured in the U.S.S.R.

carried out not only in Leningrad but also in the Kaiser Wilhelm Institut für Metallforschung, where G.V. Kourdiumov has transferred his investigations for a time. The problems which are being studied include: the decomposition of a solid solution during tempering, the compound FeO, the phenomenon of erosion of the bores of guns, the development of materials for protection against X-rays and chemical analysis by X-rays.

To obtain radiographs rapidly several designs of special X-ray equipment have been worked out in Seliakov's laboratory, in particular X-ray tubes with a rotating anti-cathode. Such tubes were found on trial to be capable of producing radiographs of the structure by the Debye method within from one to two seconds. The cameras manufactured by the Institute (Fig. 4) are now being widely used in the U.S.S.R.

At the present time the institute has undertaken the manufacture of cameras for making fine measurements of the parameter of the lattice. Now, after ten years work in the old inadequate building the Institute is being reorganized: a new building is under construction and at the same time there are being erected the physico-technical institutes in Tomsk (Siberia) and Kharkov (Ukraine). Work at this last-named institute is already in progress. The subjects of investigation are the nature of alloys, in particular of the Au-Cu compound, and the methods of obtaining high-speed exposures in the X-ray crystal analysis of metals.

The C. A.-H. Institute

In the radiological laboratory of the Central Aero-Hydrodynamical Institute in Moscow is carrying out investigations on the subject of the plastic deformation of light alloys (i. e. of duralumin) and of steels (especially of corrosion resistant steel). The writer has determined for severely-rolled duralumin the change of orientation of crystallographic axes from two axes [112] and [111], toward one axis [111].

The reduction of the metal was as high as 99.6%. Studies are conducted on recrystallization. Experiments are carried out on large-size crystals of metals in order to obtain information on the processes taking place in the crystallite within a poly-crystallite as affected by the orientation of the surrounding crystallites. Work is in progress on the structure of solid solutions, in particular on the process of aging of light alloys and of high-carbon steels. Methods of analysis at high temperatures are being developed. Special cameras for crystal analysis are being constructed. In addition, it is intended to take up certain questions relating to the technique of defects revealed by X-rays.

Other Research Institutes

In the radiological laboratory of the Institute of Non-Ferrous Metals (in Moscow), work is carried out under the direction of S. T. Konobievsky on the structure of super-hard alloys to stellite. Konobievsky is also conducting investigations on the determination of the pole shapes of deformed metal. A special camera (Fig. 6), was constructed (by G. S. Jdanoff) enabling the pole shapes to be obtained experimentally; trial tests have yielded satisfactory results.

In the radiological laboratories of the All-Union Institute of Electrical Engineering, work on X-ray crystal analysis is carried out under the direction of N. E. Uspiensky. The particular subjects of study are the texture and the recrystallization of tungsten wire, and the means of reducing the time of exposure.

Besides the producton of X-ray tubes of Vassilieff type (Fig. 7), there is elaborated a novel design of X-ray tubes for crystal analyses. Designs of equipment are worked out for the study of the structure by the ionization method. Special cameras are being constructed. X-ray examination of welds is shortly to be undertaken.

The Physico-Technical Laboratory (in Leningrad) is carrying out work on the texture of brass. At a number of other research institutes the radiological laboratories are in the stage of organization, as, for instance, at the Research Institute of Metal Working and Machine Design (Moscow), at the Institute of Metals (Leningrad), at the Oil Institute (Baku).

Fig. 4—Jwensen Type and Kourdiumov Type X-Ray Equipment for Making Radiographs by the Debye Method (Leningrad). From Left to Right: View of the Camera in Open Condition (Inside Is Seen a Test-Specimen under Investigation); the Lid with the Film-Holder; the Tube of the Camera with Slits; the Small-Diameter Demountable Film-Holder, and the Camera Assembly

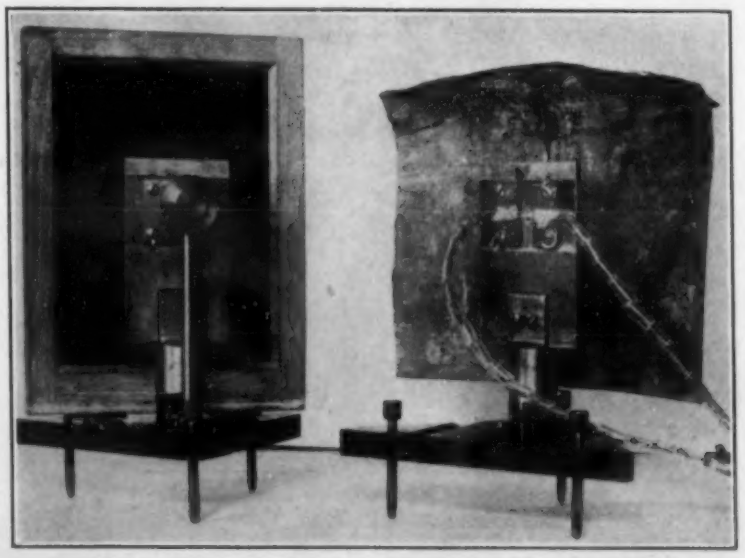

Fig. 5—X-Ray Cameras of the Central Aero-Hydrodynamical Institute for Radiographing the Texture of Metals. On the Left: Front View of the Camera Prepared for Taking a Radiograph at Room Temperature. On the Right: Rear View of the Camera (the Cassette Is Removed) for Radiographing Metals at High Temperature

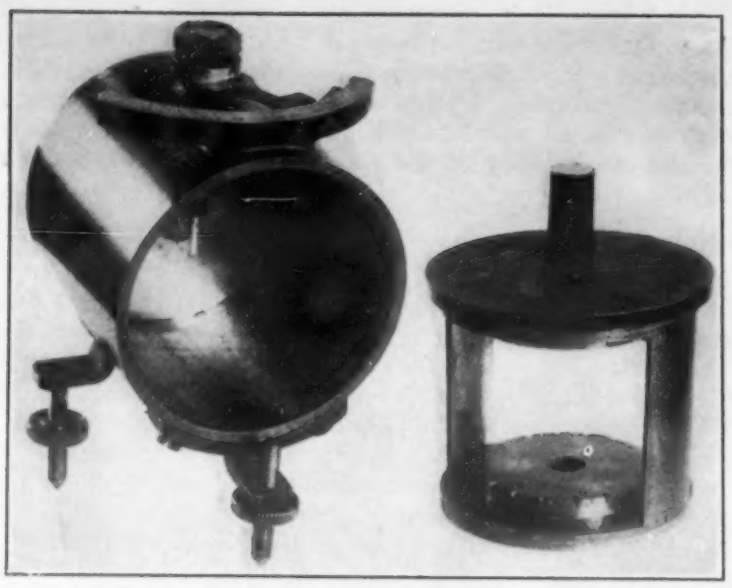

Fig. 6—A Jdanov Type Axial Camera for Radiographing the Polar Patterns. During the Exposure the Film, Inside of the Camera, Is Moved Along the Axis of the Camera Simultaneously with the Rotation of the Test-Specimen about the Axis Normal to the Axis of the Camera

Educational Institutions

It would be difficult to enumerate the objects of investigations in the radiological laboratories of educational institutions, as the research work is there closely related to the school work, the investigations are sometimes of a preliminary character and are subsequently transferred to the research institutes, or they are of the nature of control tests. In view of the reorganization of the whole system of college education, which is now being carried into effect in the U.S.S.R., it would also be difficult to give an account of the training received by future research workers in the field of the X-ray examination of metals. It may only be mentioned that special courses on radiology are given at the Polytechnical Institute in Leningrad, at the first University of Moscow, at the Pliechanoff Memorial Institute, and at the Moscow Technical High School. As a result of the reform of college education, radiology is to be taught at a number of other educational institutions, at which radiological laboratories are now being established, as, for instance at the Air Academy, and at the Lomonossoff Memorial Institute.

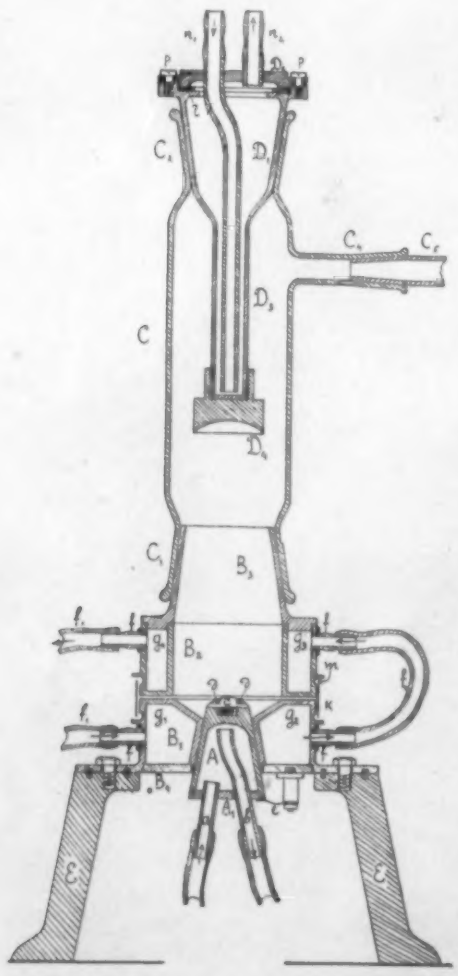

Fig. 7—A Demountable Hadding Type Tube of Vassilieff Design of Glass, for X-Ray Crystal Analysis, Permitting the Simultaneous Operation of Several Cameras. As the Polished Metallic Surface of the Anti-Cathode, with the Removable Anti-Cathode (c) Provided with Grooves for Screwing in (d). B_1 B_2 B_3 B_4 E—the Metallic Lower Portion of the Tube with the Polished Section, with an Annular Filter of Aluminum (k). C C_1 C_2—the Glass Central Portion of the Tube with the Polished Sections and with a Connection of Exhausting the Air (C_4 C_5). D_1 D_2 D_3—the Metallic Upper Portion of the Tube with the Polished Section, with a Rubber Gasket (r) with a Demountable Cathode Mirror (D_4). a c f f_1 g_1 g_2 g_3 g_4 n_1 n_2—the Cooling System of the Tube

Industrial Research Laboratories

In a brief article it is difficult to give an outline of metal research carried out at various industrial plants in the U.S.S.R. We shall confine ourselves to a few examples.

The radiological laboratory at the Mariupol works has undertaken a series of tests on internal stresses. By the methods of X-ray spectrographic analysis is determined the content of arsenic in ores, slags and cast-iron. These methods are also applied to determine the atomic arrangement in manganese and in high-speed steels. Studies are conducted on forge-welded tubing. A comprehensive investigation is in progress on foundry lining bricks. The researches are carried out under the direction of B. J. Peenes.

At the Ijewsky and at the Motovilikhinsky works (Ural) a series of preliminary investigations was undertaken by the radiological laboratory under the direction of G. J. Aksenov, to determine the presence of cracks in steel shafts by X-ray examination. The method is found to be satisfactory. A comprehensive theoretical investigation is now completed on the analysis of elastic deformation by the Debye method and experimental work in this direction is under way.

In the radiological laboratory at the Electrical Works (Moscow) the treatment of tungsten by X-ray crystal analysis is studied and X-ray examinations of castings are made.

Engineers and Physicists

The Second All-Union Conference on Metal Research, which was held in Moscow in May 1930, fully demonstrated the extensive use of radiology in the U.S.S.R., as well as that intimacy which is growing between physicists and engineers concerned with the study of metals and alloys.

At the Conference, which was devoted to the subject "The Plastic Deformation of Metals" there were read and discussed in all 27 papers of which 14 were reports of investigations based on the X-ray method. Forty percent of the attendance were engineers, 45% physicists and 15% students and members of other professions.

Papers on the investigation of metals by the X-ray method are also published in the foreign technical press, and in the following journals printed in the U.S.S.R: "The Metal Industry Messenger," "Journal of the Russian Metallurgical Society," "Engineers Messenger," "The Journal of Applied Physics," "The Journal of the Russian Society of Physics and Chemistry" (Physics Section), "Progress of Physical Science," "The Scientific World," "Physics and Industry," etc.

A large number of investigations are published as monographs, either by the laboratories or by the State Technical Press Publishing Office. The latter publishes the majority of investigations carried out at the engineering research institutes in the U.S.S.R. under the general title "Transactions of the Scientific Research Division of Planning, Engineering and Economics Administration of the Supreme Council of National Economy."

Contact with Other Countries

Besides the information obtained from technical journals, the research institutes and laboratories in the U.S.S.R. are in touch with the radiological laboratories of other countries by means of an exchange of monographs and directly through members of their staff, working abroad.

Unfortunately, foreign journals are often very much delayed (France, England), and sometimes there are gaps in delivery (U. S. A., Japan). Matters are particularly bad as regards those submitted at foreign colleges and monographs published by individual laboratories and research institutes. In this respect one might wish a closer connection and more friendly intercourse between workers of research laboratories throughout the world.

Correlated Abstract

Dr. Gillett, the editorial staff and specially selected contributors will prepare abstracts reviewing the work recently reported pertaining to certain subjects. These reviews will take into consideration the work of a number of workers.

The Occlusion of Hydrogen and Nitrogen by Pure Iron and Some Other Metals**

By Dr. Erich Martin*

The investigation of J. Parry[1] in 1874 on the occlusion of hydrogen by iron may be considered as the first fairly accurate work done on the subject. His method of heating the metal in a vessel of known volume and of measuring the expansion of the gaseous atmosphere has often since been applied in investigations of the kind.

The next outstanding work on occlusion of gases by pure iron and some of its alloys was done by Adolf Sieverts and his coworkers.[2] He used a quartz bulb heated in a platinum resistance furnace and connected with a calibrated burette by capillary glass tubes. A blank expansion curve was obtained by heating the metal in an inert gas (nitrogen or argon). The relative position of the hydrogen expansion curve to the blank curve gave the amount of hydrogen occluded at the various temperatures.

In 1926 Keizô Iwasé[3] published results on the occlusion of gases by iron which differ considerably from the results obtained by Sieverts. Iwasé used almost the same apparatus as Sieverts, but he changed the method in the following way. Instead of taking a blank curve he evacuated the quartz vessel containing the metal at various temperatures. Then he allowed the gas to enter and calculated the amount occluded from the reduction of the mercury level in the burette. As a matter of fact this method is not as accurate as that of Sieverts.

The object of the following investigation was first to check the results of Sieverts and Iwasé concerning the occlusion of hydrogen and nitrogen by pure iron. In addition, the author endeavored to secure additional data as to the influence of some metals on the occlusion of gases by iron.

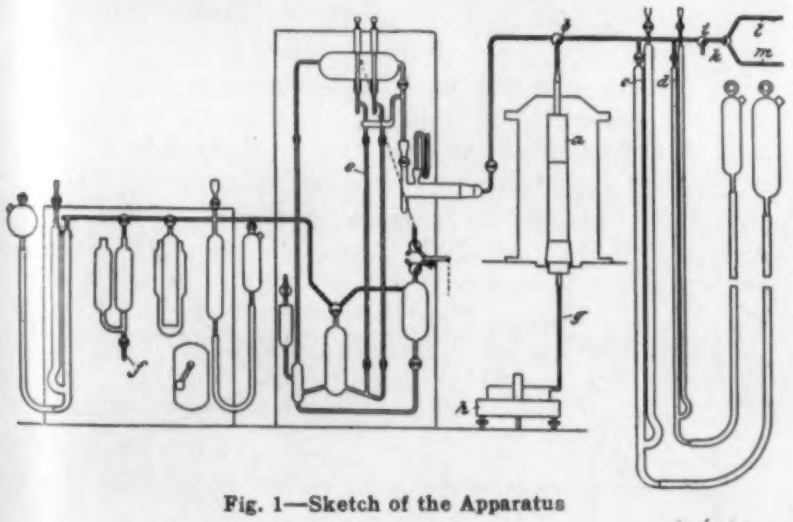

Fig. 1—Sketch of the Apparatus

In Fig. 1 a sketch of the apparatus is given; "a" is the furnace containing the vessel. Attempts were made to use porcelain tubes in order to be able to work at high temperatures. Yet no results could be obtained though different porcelain materials were tested. At temperatures higher than 700° to 800° C. a marked reduction of the porcelain by hydrogen can be observed. For that reason the author had to confine himself to the use of tubes of fused silica. This material cannot be used at temperatures higher than 1250° C. The shape of the vessel is shown in Fig. 2. The crucible containing the metal is placed at the bottom of the outer tube. The inner tube is used to keep the dead space of the vessel as small as possible. It is connected with the outer tube by a ground and greased joint. The outer tube has a nozzle leading to the burettes. By turning the stopcock "b" the silica tube can be connected with the burettes or the mercury pump "e" as designed by Oberhoffer and Beutell.

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This pump and the gas analyser "f" are the same as used in the hot-extraction method for the determination of oxygen in steel according to Oberhoffer and Hessenbruch.[4] The burette "d" has a capacity of about 35 cc. with 0.05 cc. subdivisions so that it is possible to estimate 0.01 cc. after some experience with the apparatus. As it proved to be very difficult or almost impossible to manufacture the tubes with the small dead space desired it became necessary to use a second burette. This has a capacity of about 120 cc. "l" and "m" are capillary glass tubes for the supply of hydrogen and nitrogen. Pure hydrogen was produced by electrolytic decomposition of sodium hydroxide. The apparatus described by Oberhoffer and Keutmann was used.[5] The nitrogen was purified according to L. Moser.[6]

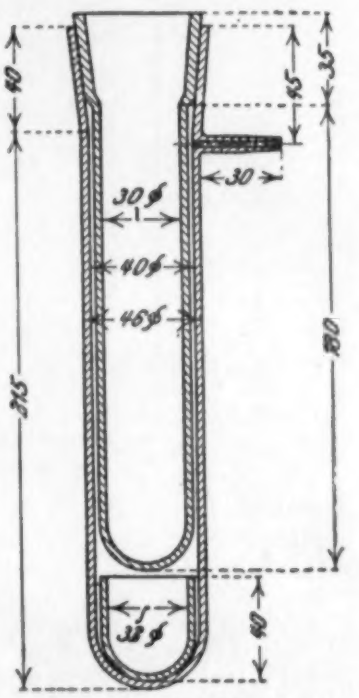

Fig. 2—Fused Silica Vessel

The platinum-platinum-rhodium thermocouple was standardized by the melting points of tin, antimony, copper and nickel. By shifting the thermocouple along the vertical axis of the furnace it was possible to obtain the correct temperature curve of the furnace. The furnace is shown in Fig. 3. The vessel is heated by a carbon spiral placed into the body of the furnace. Through the bottom a porcelain cylinder reaches to the center of this cylinder and touches the bottom of the silica tube. The latter is fixed to the cover by means of Picein wax. Porcelain cylinder and silica tube are protected against the direct radiation of the carbon spiral by a quartz tube "d." "c" is a glass vessel for cooling the upper end of the silica tube. The free space of the inner tube is filled with silica pieces. Special provisions are made in order to evacuate the furnace and the inner silica tube or to flush them with gases, so that the conditions in- and outside of the silica tube may be kept equal. By this arrangement it is possible to avoid diffusion through the silica walls. It is necessary to use a carbon spiral 270 mm. in length to obtain a constant temperature zone of at least 50 mm. When heating the furnace the water of the different jackets was always kept at certain temperatures corresponding to the different temperatures of the furnace. Thereby it was possible to obtain the same temperature curves for the furnace during different experiments. The accuracy of the whole method depends on this possibility. The zone of constant temperature was about 60 mm. long, so that the temperature measured at the bottom of the silica tube gave that of the metal in the crucible with an accuracy of about ±1–2° C.

Argon was used as the inert gas for the blank curves. According to Ramsay and Travers[7] argon cannot diffuse through red hot platinum, palladium or iron. Sieverts and Bergner[8] found no occlusion of argon by any metal. This fact results, as will be seen below, also from the observation that the argon expansion curves do not show any displacement whatsoever at melting or critical points of metals. The results obtained by using argon for the blank curves may, therefore, be considered as representing the absolute values.

The procedure of a determination is as follows. The crucible containing the metal is placed in the silica tube and the vessel connected with the mercury pump in order to test the apparatus

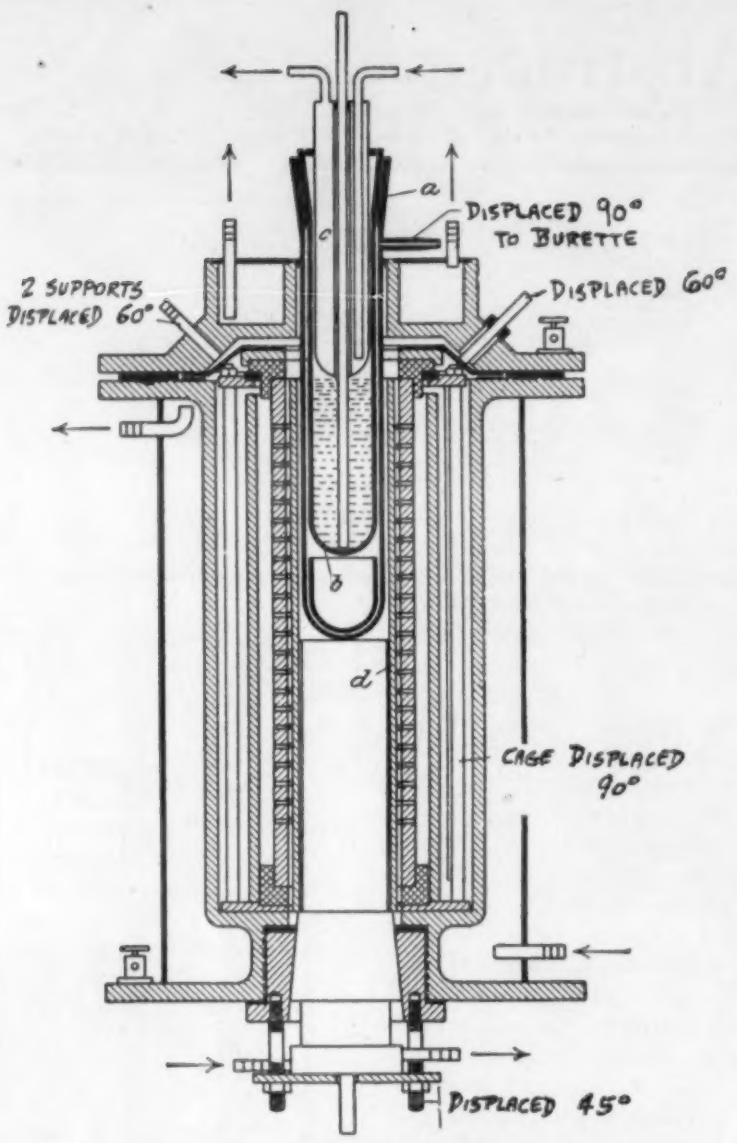

Fig. 3—Carbon Spiral Furnace

at room temperature. The metal then was heated in vacuo to extract all gases. At about 1250° C. hydrogen was allowed to enter and reduce metal oxides if present. After a treatment with hydrogen of at least 1 hour the tube was evacuated again and cooled in vacuo. The tube was filled with argon after complete equilibrium with the room temperature was reached. An excess pressure amounting to the difference between the actual barometric pressure and 760 mm. was always maintained in the open leg of the burette "d." As the pressure in the tube was always equal to 760 mm. no provision had to be made for the change in barometric pressure. Starting from room temperature the furnace was heated to various temperatures. If no further change of the mercury level in the burette took place at constant temperature, equilibrium was attained and maintained for at least 1 hour. The level of the burette then was read and the furnace heated or cooled to another temperature. All readings were made in burette "d" which is kept at known temperature by a water jacket. After this was entirely filled with gas, the tube was disconnected from the burette by means of the stopcock "b." The gas from burette "d" then was taken into burette "c.' After this, burette "c" was disconnected and the tube and burette "d" again connected. In this way it is possible to obtain the expansion curves for all gases up to

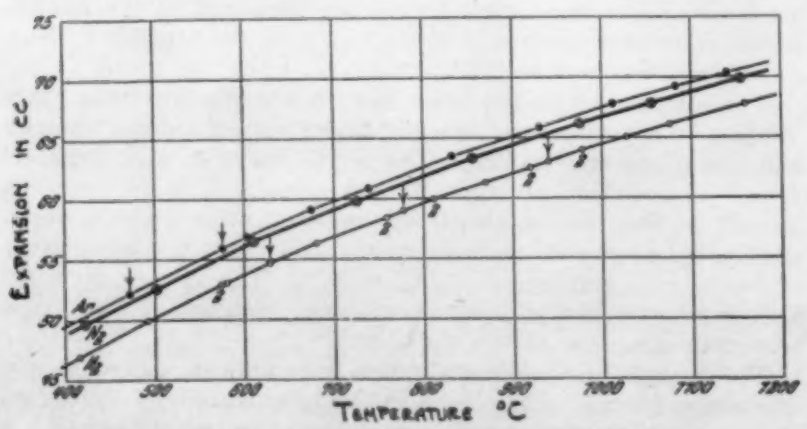

Fig. 4—Blank Curves for Argon, Nitrogen and Hydrogen

1250° C. True equilibria are measured if the points found by heating and cooling are situated on the same curve.

Expansion curves obtained with argon, hydrogen and nitrogen without using any metal in the crucible are shown in Fig. 4. The points marked by arrows were as obtained on cooling. It is evident that the 3 curves over the whole range of temperature observed have constant distances one from another. The argon curve shows the largest expansion, and is located 0.75 cc. above the nitrogen and 3.00 cc. above the hydrogen curve. Due to the much higher thermal conductivity of hydrogen the furnace requires 4–5 amp. more than when using nitrogen. At the same time the heat of the carbon spiral is more rapidly transferred to the water jacket. This results in a steeper temperature curve of the furnace. The lower expansion of the hydrogen is thereby explained.

In the hydrogen curve some points marked by "2" are given. These correspond to experiments made on other days. The accuracy of the method as shown by the comparison of the points is in most cases better than ±0.08 to 0.10 cc. According to the different weights of the samples this accuracy is of more or less influence on the final results as these are given in cc. of gas occluded by 100 gm. of the metal.

The path of the curves shows the curves of the 3 gases that should be expected if no occlusion of hydrogen and nitrogen takes place. If other curves for hydrogen or nitrogen are observed the difference between the curves is the amount of gas occluded by the sample.

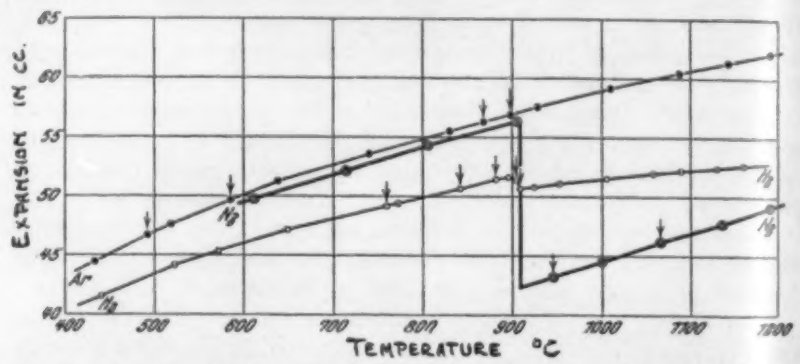

Fig. 5—Experimental Results for Pure Iron and Argon, Nitrogen as Well as Hydrogen

For the investigation of the occlusion of hydrogen and nitrogen by pure iron a very pure electrolytic iron in the form of a 0.3 mm. sheet was used. The chemical analysis of this material was:

C	trace—0.007%	Si	trace
Mn	trace—0.008%	P	trace—0.0006%
Cu	0.007%—0.008%	O_2	0.002%

The iron contains only about 0.02% of impurities. It was reduced by hydrogen for 6 hours at 1250° C. The sample weighed 84.08 gm. At 1200° C. no reduction of the mercury level was observed in a hydrogen atmosphere during 2 hours.

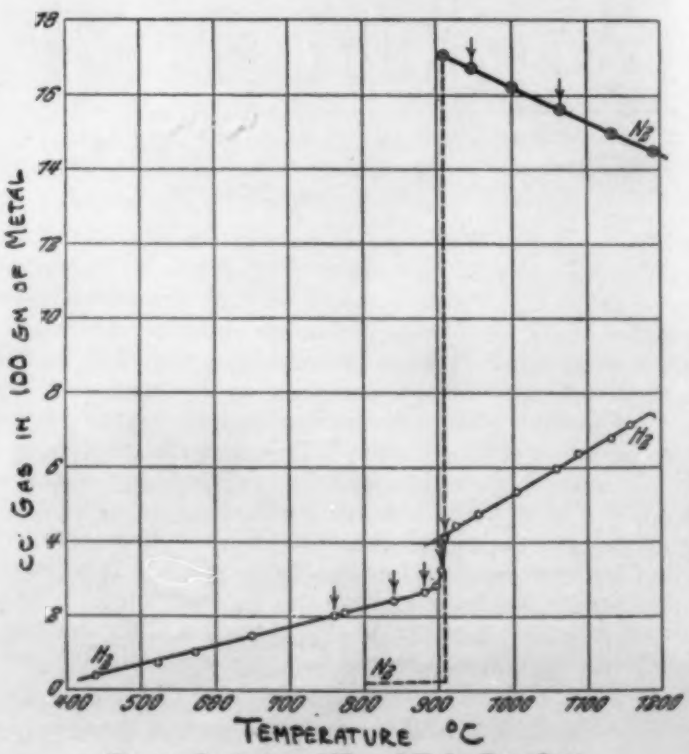

Fig. 6—Occlusion of H_2 and N_2 by Pure Iron

The sample was cooled in vacuo. The curves were obtained as described above. Whereas the equilibria between hydrogen and iron were reached almost instantaneously, the equilibrium between iron and nitrogen at 1000° C. required a very long time (16 hours). After this first equilibrium in the γ-range was reached the other equilibria above 900° C. were obtained quickly, the same was true below 900° C. The curves for argon, hydrogen and nitrogen are given in Fig. 5. The points marked by arrows show that in all cases true equilibria have been obtained. The curves for hydrogen and nitrogen show very pronounced displacements at the α-γ-transformation point, whereas the argon does not show any influence of the critical point. The values for the occlusion of hydrogen and nitrogen by pure iron are given in Fig. 6. The occlusion of hydrogen begins at about 400° C. and increases slowly up to 900° C. At that point the curve shows a displacement and the amount of gas occluded increases from 2.9 cc. to 4.2 cc. Above this temperature the curve again increases with the temperature. Both parts of the curve may be considered as linear, yet the slope of that in the γ-range being higher than that of the α-range.

Preliminary experiments showed that there is a certain amount of nitrogen occluded by pure iron below 900° C. Yet it could not be determined later. The displacement of the curve at the transformation point is considerably higher than in the case of hydrogen. The amount of nitrogen occluded, however, decreases in the γ-range with increasing temperature.

In Fig. 7 a comparison of the results of Sieverts, Iwasé and this investigation is given. There is only a small difference between the hydrogen curves found by Sieverts and by the experiments described in this paper. The transformation point is not very sharply marked, no sudden displacement of the curve takes place in the curve found by Sieverts. This is probably due to the fact that the temperature was not quite uniform in his sample so that the transformation took place during a certain range. Jurisch, one of the co-workers of Sieverts, discusses this.[9] As in the experiments presented here great stress has been laid on the accurate control of the temperature conditions it may be concluded that the marked displacement found at the transformation point represents the actual path of the curves. As a matter of fact, this should be expected from the application of the phase rule to the system. The agreement of the nitrogen curves of Sieverts and this paper is also very good. The curves given by Iwasé on the contrary show very considerable deviations. The hydrogen curve at 1000° C. reaches almost 5 times the value of the other curves found for hydrogen. The nitrogen curve is very low compared with the other curves. It is striking that Iwasé in no case found an increase in amount of gas occluded at the transformation point. His curves only show a change in the slope. He observed that the equilibria between hydrogen and iron could not be obtained without heating at constant temperature for several hours. This seems to indicate that his "ferrum reductum" still contained some FeO. The high values found for the occlusion would be due to the reduction of FeO. Yet it seems to be hard to explain the low values obtained by Iwasé for the occlusion of nitrogen by pure iron.

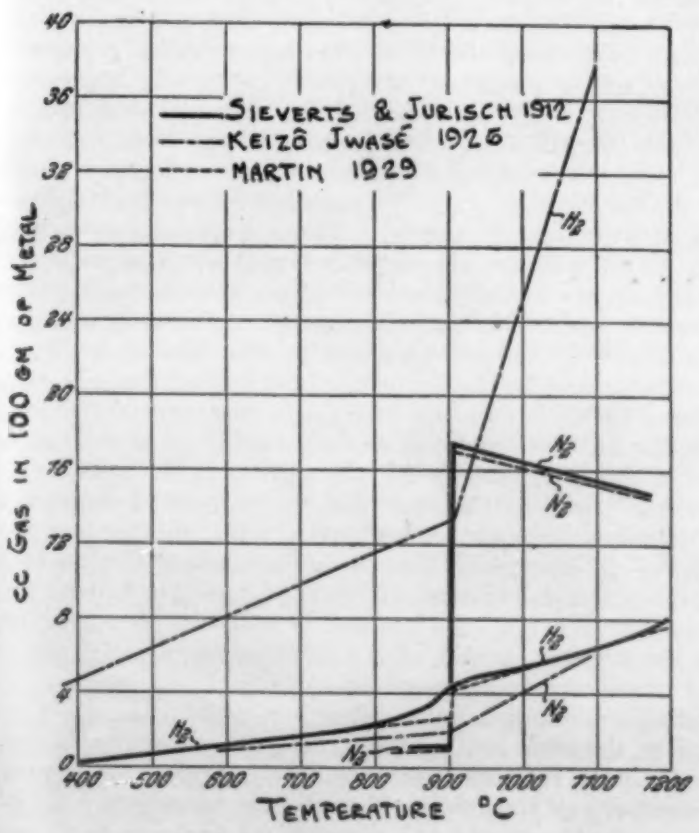

Fig. 7—Results of Sieverts, Jwasé and the Author

From the excellent agreement of the results of Siéverts and those of this paper the conclusion may be drawn that the values given by Iwasé are too high for hydrogen and too low for nitrogen.

Different authors who worked on iron and nitrogen[10] agree that elementary nitrogen cannot combine with iron even at high temperatures and pressures. The iron nitride formed by passing ammonia over iron gradually decomposes above 450° C. Taking these facts into consideration it seems evident that the nitrogen occluded by iron in the γ-range is present as a solid solution of the gas itself and not of a compound, at least not of the compound known as iron nitride.

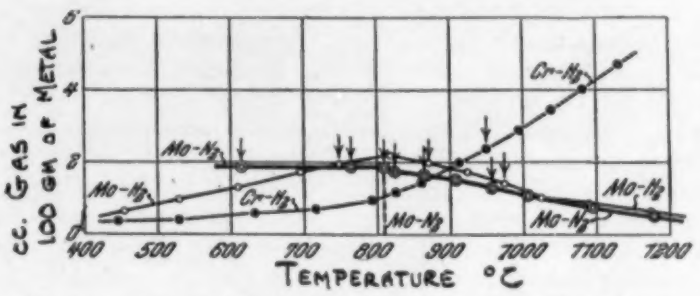

Fig. 8—Occlusion of H_2 and N_2 by Chromium and Molybdenum

The occlusion of hydrogen and nitrogen by chromium was investigated by using Goldschmidt chromium. The metal was pulverized. The results for hydrogen are shown in Fig. 8. The amount occluded is very small yet increases above 800° C. Less hydrogen is occluded than by iron. The curve represents true equilibria.

Hüttig and Brodkorb[11] in their investigation on the properties of chromium which was electrolytically charged with hydrogen observed a strong evolution of gas when heating the metal above 58° C. They characterize the state of the metal as supersaturated. In fact the amount of hydrogen in equilibrium with chromium at low temperatures should be expected to be very small as shown by the curve in Fig. 8.

Up to 550° C. no occlusion of nitrogen by chromium was observed. At 625° C. a reaction between chromium and nitrogen took place. The speed of this reaction at 975° C. was determined to be almost 270 times as high as that at 625° C. Even at 1200° C. and the very low pressure of 0.001 mm. mercury no nitrogen was given off by the metal. The dissociation pressure of the compound formed must be very low. The metal was cooled in vacuo. The appearance had changed to a light gray. It had absorbed 1335 cc. of nitrogen and the increase in weight, to be expected, was 1.67 gm. The actual increase in weight was determined as 1.70 gm., which is pretty close to the theoretical value. It may be seen from this fact that no dissociation had taken place at the low pressure and high temperature.

Contrary to the determination of Baur and Voermann[12] the dissociation pressure was found to be very low. Adcock[13] in his work on the influence of nitrogen on some iron-chromium alloys states that alloys containing 11.82% Cr contain 0.12% of nitrogen, alloys with 24.6% Cr, 0.27% of nitrogen. Chromium increases the occlusion of nitrogen by iron considerably. In these cases a compound probably is formed, only chromium nitride or a double nitride similar to the double carbides. That in spite of the low dissociation pressure of the chromium nitride the nitrogen can easily be extracted by the hot extraction method is due to the fact that the affinity of iron for chromium at the high temperatures of 1500 to 1600° C. is much greater than that for nitrogen.

The molybdenum tested was a 0.1 mm. sheet of high purity. It was obtained from the Osram Co., Berlin. The occlusion of hydrogen by molybdenum is very low and, especially at higher temperatures, considerably lower than that of chromium. The curve is given in Fig. 8. The path of the curve is very striking as it reaches a maximum at about 800° C. The 2 parts of the curve are almost symmetrical. The curve gives true equilibria. Up to 800° C. molybdenum does not occlude any traceable

amount of nitrogen. At that temperature about 2.00 cc. are absorbed but the curve falls with rising temperature almost coinciding with the hydrogen curve. When cooling down the amount of nitrogen occluded at 800° C. is not given off. It can be extracted only by lowering the pressure.

Vandenberghe[14] and Lorenz and Woolcock[15] have found no absorption of any "marked" amount of nitrogen by molybdenum. Yet the apparatus used in these investigations did not permit the determination of such small amounts as 2 cc./100 gm.

A very pure tungsten powder as used for the manufacture of incandescent lamps was examined. The experiments showed that within the range of temperature from 400 to 1250° C. neither hydrogen nor nitrogen is occluded. Sieverts found no occlusion of hydrogen by tungsten when using nitrogen as blank gas.[16] By comparing the curves for argon and nitrogen it was shown by the experiments presented here that actually no occlusion of nitrogen takes place.

In order to get some data on the influence of silicon on the occlusion of gases by pure iron, 4 different alloys were made. The vacuum melted electrolytic iron of Heraeus, Hanau after again melting under vacuum has the following analysis: C—0.023%, Si—0.022%, Mn—trace, P—trace, S—trace, O_2—0.0048%. The silicon of chemical purity was obtained from Merck, Darmstadt. The silicon powder was placed in holes drilled in the iron samples. The alloys were melted in a high frequency vacuum furnace. The pressure during melting was about 0.03 to 0.01 mm. mercury. Two of the melts were made high enough in silicon so that the alloys would have no γ-range. The 4 melts had the following silicon contents: melt I—0.55%, melt II—1.68%, melt III—3.05% and melt IV—5.10%.

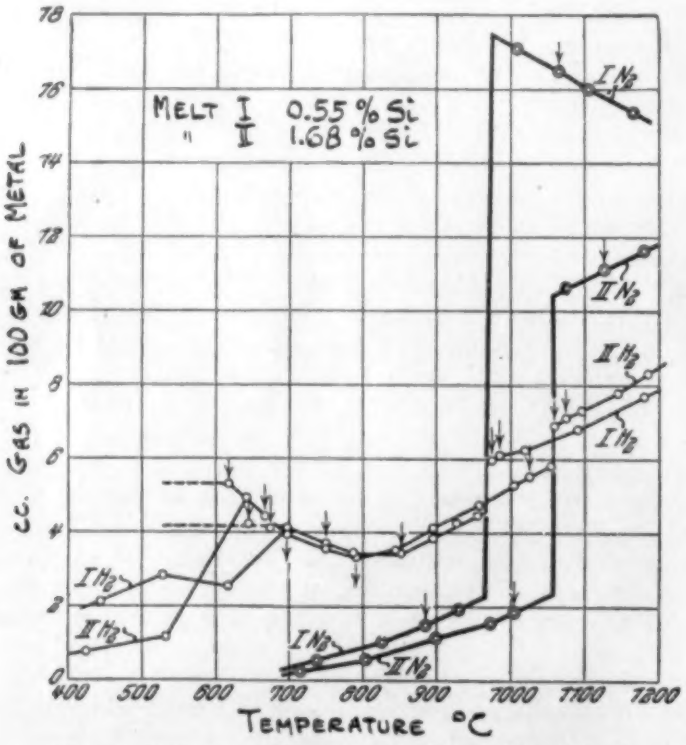

Fig. 9—Occlusion of H_2 and N_2 by Iron-Silicon Alloys

In Fig. 9 the results for melt I are given. It is very striking that the curve for the occlusion of hydrogen shows considerable variations below 800° C. It is only from this temperature that it increases steadily. The transformation point is situated at 965° C. At this point the amount of hydrogen increases from 4.6 to 5.9 cc./100 gm. By cooling the metal it is possible to trace the curve back to 700° C., i. e., the curve only represents true equilibria above this temperature. The amount of hydrogen occluded at this temperature is not given off by further cooling. It may, however, be extracted by evacuation. The values for the occlusion of hydrogen for this alloy are higher than those for pure iron only below 800° C.

The occlusion of nitrogen in the α-range is increased by silicon. The equilibria in this range are quickly reached. The equilibrium at 1008° C. though required 8 hours. After this equilibrium was obtained the other equilibria were fairly quickly reached in the γ-range. When cooling again to the α-range it required only 2 hours to attain equilibrium. This seems to indicate that in the range of higher occlusion the speed of diffusion is lower than in the range of smaller occlusion. Though occlusion is impossible without any diffusion, this seems to show that at least in this case no quantitative relation between the rate of diffusion and occlusion exists.

The values for melt II are also given in Fig. 9. The hydrogen curve shows quite a similar path below 800° C. From that temperature it almost coincides with that for melt I, yet the transformation takes place at 1055° C. At this point the amount occluded increases from 5.8 to 6.9 cc./100 gm. In the α-range the values for the occlusion of nitrogen are somewhat lower than those for melt I. In contradiction to the path of the nitrogen curves for pure iron and melt I the curve of melt II increases in the γ-range with increasing temperature. The

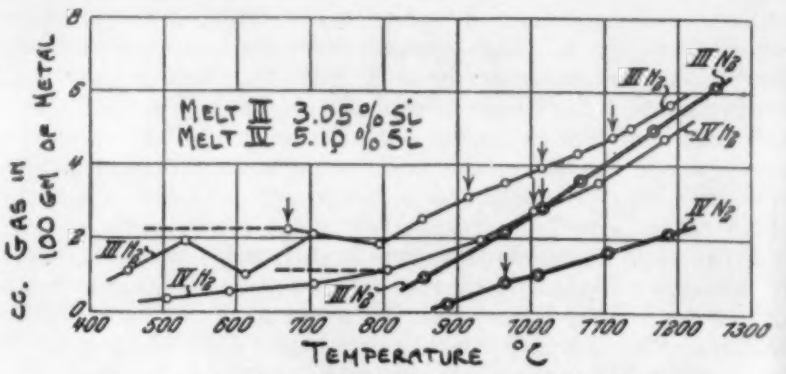
MELT III 3.05 % Si
MELT IV 5.10 % Si
III N2
IV N2
III H2
IV H2
CC. GAS IN 100 GM OF METAL
0 2 4 6 8
400 500 600 700 800 900 1000 1100 1200 1300
TEMPERATURE °C

Fig. 10—Occlusion of H_2 and N_2 by Iron-Silicon Alloys

equilibrium at 1075° C. required 4 hours. When cooling the metal below the transformation point equilibrium required only 1½ hours.

Fig. 10 gives the results for the melts III and IV. The hydrogen curve for melt III still shows displacements at lower temperature. It may be possible that the curve for melt IV should have a similar path. Yet on account of the small weight of the sample (31.67 gm.) and the lower accuracy resulting therefrom it may have escaped determination. Both curves are lower than that of pure iron above 900° C. In both cases the hydrogen occluded at a certain temperature is not given off by further cooling. Below these points the curves do not represent equilibria. The nitrogen curves, however, give the true equilibria.

Though there has been up to the present no quantitative indication[17] it was a quite frequent opinion that silicon should considerably increase the amount of gases occluded by iron. The effect of silicon as a deoxidizer was partly ascribed to this assumed property. The curves given here do not confirm this opinion, on the contrary they show that the influence of silicon in the range of temperature and concentration examined is only very small. It is rather difficult to compare the results of the 4 melts with each other. Two of them have no γ-range, and besides that the melts at the same temperature may be in different ranges (α or γ). Melt II shows the greatest occlusion of hydrogen. It does not seem possible to give an explanation for the irregular paths of the hydrogen curves at lower temperatures. As no effect on the A_2 point was observed with pure iron it seems improbable that the curves should be influenced by this point. Steacie and Johnson[18] in their investigation on the occlusion of oxygen by silver found a minimum in the absorption curve. Borelius[19] when degasifying iron noticed a periodical increase in the amount of gases given off. This would indicate minima of occlusion at these points. It is difficult to say if there are any connections between these observations and the curve found for the occlusion of hydrogen.

Graham[20] in his investigations on the relation of hydrogen to palladium calls the metal charged with hydrogen an alloy between palladium and the "metal hydrogenium." This seems to be the first conception of the fact that in most cases of occlusion of gases by metals we are dealing with solid solutions. Hoitsema[21] proved that no chemical compound is formed by the action of hydrogen on palladium. He was the first to give a survey on the possible causes of occlusion. The path of the absorption curves indicates whether there are 2 or 1 phase present in the metal. Yet it is impossible to decide from the curves whether a phase consists of a solid solution of gas in the metal or of a gas-metal compound in the metal.

Palladium acts in a quite different way from the other metals near it in the periodical system. Sieverts and Gotta[22] therefore, consider it as forming "semi-metallic hydrides" on account of the similarity of its action with titanium, vanadium, zirconium, niobium, tantalum and the elements of the rare earth metals.

The term "hydride" here means nothing else than any form of a combination or occlusion of hydrogen with metals.[23] The real chemical compounds are called "salt like hydrides" and the hydrides representing a real solid solution "metallic hydrides." In the periodical system the "salt like hydrides" of the alkali- and alkaline-earth metals are followed on the right by the metals of the III and IV group forming the "semi-metallic hydrides." These hydrides cannot be looked upon as metallic on account of their appearance, yet the path of their absorption curves clearly indicates that these hydrides represent solid solutions. The metals of the groups VI and VII lead to the "metallic hydrides" of the VIII and I groups. In these hydrides the hydrogen atoms can move freely in the lattice,[24] whereas in the case of lithium hydride which is a chemical compound the hydrogen atoms have certain fixed places in the lattice. Huettig claims "to be able to prove by some more experimental data, that all solid hydrogen-metal combinations may be considered as parts of an essentially continuous transition between these 2 extremes." He assumes that there is a distinct equilibrium characteristic for each metal between the amount of hydrogen atoms moving freely and those which are fixed.[25] In the extreme cases one of them may not be noticeable. The law of constant and multiple proportions then would only be an ideal case of a more general behavior.

The occlusion of gases by metals of the VIII and I groups, as a rule, increases with the temperature. This is quite an exception which is characteristic only of the metallic state. The assumption must be made that the retention of the gas is relatively stronger at higher temperatures. The increase in the amount of gas occluded is commonly explained by the thermal expansion of the lattice, which allows more and more atoms to enter the lattice.[26]

For all metals examined it was found that the amount of gas occluded at constant temperature is $m = k\sqrt{p}$, i. e., is proportional to the square root of the pressure of the gas. (Sieverts and others.) Borelius and Lindblom[27] changed this formula to the expression: $m = k(\sqrt{p} - \sqrt{p_t})$. $\sqrt{p}$ is greater than $\sqrt{p_t}$ and p_t is an initiating or minimum value of the pressure, beyond which no occlusion at all takes place. From this relation to the square root of the pressure it was concluded that the hydrogen (and as far as examined also the nitrogen) enters the metal in form of atoms, so that a solid solution of metal- and gas atoms is formed. This explanation holds for the diatomic gases. Yet it does not explain the fact that this law was also found for the occlusion of SO_2 by copper. Nevertheless it is considered as certain that hydrogen is split into atoms when forming a solid solution with metals. To be correct one should assume that the gas already dissociates before entering the metal forming a thin layer of monatomic gas and thus causing the fact that the occlusion depends on the square root of the pressure exerted by the gas in the diatomic form. Richards and Behr[28] and Richards and Richards[29] found in their investigation on the influence of magnetic fields on iron charged with hydrogen, that the gas is dissociated into atoms but not ionized. Bennewitz and Günther[30] and Schmidt[31] however concluded from their experiments that the hydrogen occluded by platinum is entirely ionized to positive ions and negative electrons.

The thermal expansion of the lattice seemed to give quite a reasonable explanation of the increase of the occlusion with the temperature. Yet it is impossible to draw any quantitative conclusion from this assumption. At 1000° C. 100 gm. of pure iron occlude 16.25 cc. of nitrogen but only 5.25 cc. of hydrogen, though the 2 gases have almost the same atomic volume. Besides that, the conception of the thermal expansion does not seem to agree with the changes at the transformation points of pure iron and iron silicon alloys. At the A_3 point of the body centered cubic lattice of the α-iron changes to the face centered cubic lattice of the γ-iron. According to Honda[32] the change from the geometrical standpoint may be considered as a change from a body centered cubic lattice with the space lattice of 1 to a body centered cubic lattice with the space lattice of $^1/_2\sqrt{2}$. The transformation would be nothing but a contraction of the space lattice from 2.90 A. U. to 2.56 A. U. In spite of this contraction which as a matter of fact is already well known from dilatometric investigations, the occlusion of gases at the transformation points increases in all cases, i. e., is higher in the γ-range than in the α-range.

The experiments of Brace and Ziegler[33] seem to give an indication that the γ-δ transformation accompanied by a dilatation of the space lattice causes a decrease in solubility of gases. These authors melted iron in a high frequency vacuum furnace and noticed a marked increase in pressure just below the melting point. At least it is not impossible that this increase in pressure is the result of a decrease in solubility.

The experiments presented here and the attempt to show the relationship between these and results already known before with the theory of the atomic arrangement clearly indicates that it is very difficult to draw definite conclusions. This can be done only after much more experimental data have been secured.

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Extended Abstract

Selected articles that appear to be of outstanding importance or interest will be abstracted in this section at greater length than Abstracts of Current Metallurgical Literature. The important points will be given fully enough to obviate for the purposes of most readers, the necessity of going to the original article, but in a distinctly condensed form. These abstracts are not critical.

Cutting Tests with Cemented Tungsten Carbide Tools

By T. G. Digges*

Condensed by Samuel L. Hoyt**

The author states that "This investigation was made for the purpose of developing a method of testing cemented tungsten carbide lathe tools under heavy duty and to extend to the new cutting material some of the empirical laws originally developed by Taylor and his associates for rough turning with carbon and high speed steel tools, and concludes that "The so-called lathe breakdown test for high speed steels was found applicable for testing cemented tungsten carbide tools under heavy duty." This is important because it guarantees to the engineer that dependability and reliability of performance which he requires of any engineering material. The application of these tools in practice is not as simple as this however and this guarantee, as well as the tests described by the author, relate more to the inherent cutting ability of cemented tungsten carbide and to its latent possibilities as a cutting tool.

After commenting on the present prominence of tungsten carbide as a tool material the author continues "The experiments described in this report relate primarily to a study of lathe tool performance as affected by the conditions of cutting, such as, variations in speeds, feeds and depths while the composition, the size and form of the tools and cutting materials were not varied." Results of months of tests of this type the author has summed up as formulae which will be reproduced later.

Table 1
Chemical Analysis Representative of the Cemented Tungsten Carbide Tools

Lot No.	Chemical Composition—% C	W	Co	Fe
1	5.3	81.4	12.7	0.76
2	5.3	81.2	12.6	0.66

The cutting tests were carried out on a 36 inch heavy duty engine lathe, driven by a 40 horse power, 220 volt D. C. shunt wound motor through a "Link Belt" chain drive (see Fig. 1). Speed changes were accomplished by several gear ratios and by changing the speed of the motor with a variable resistance in the field circuit. Other features of these tests were a "live center" in the tail stock and a special tool holder which gave ample support to the test tool near the cutting edge.

The tool proper was a standard general purpose lathe tool of the Carboloy Company, 1/2 inch × 1 inch × 7 inches and is shown in Fig. 2. The cemented tungsten carbide tip was secured to the end of the tool by copper brazing, while chemical analysis showed that it contained about 12.7% Co, 5.3% C, 81.3% W and 0.7% iron.

Inasmuch as uniformity of performance was one of the vital features under study in these tests, the author selected his conditions to eliminate the effects of any possible variations in the test log and repeated each individual test a number of times.

* Bureau of Standards.
** Research Laboratory, General Electric Company.

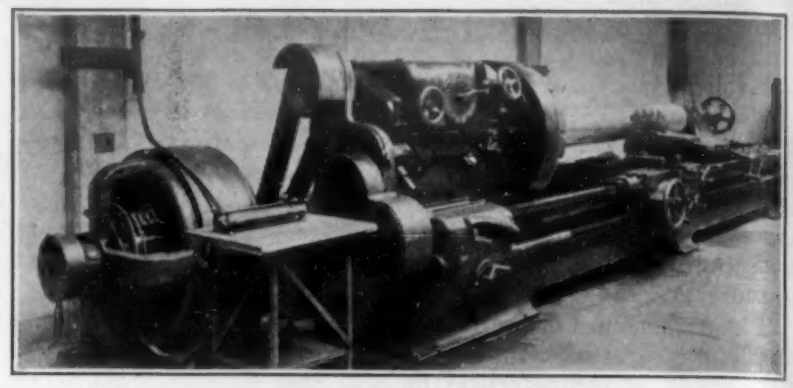


Fig. 1—Lathe Used in Tool Tests

This method of testing "in sequence" has long been used and, with the individual values agreeing well among themselves, the average values obtained can be used with considerable confidence.

The test logs were annealed nickel steel, originally from 10 to 12 inches in diameter and from 8 to 10 feet in length. The mechanical properties were obtained for each forging with the results as given in the accompanying table. All tests were run dry.

The end of the test or the moment the tool lost its useful life was obtained in the following way: "A groove was formed on the top surface of the tool near the 'leading edge' soon after the tool started to cut. This depression became greater

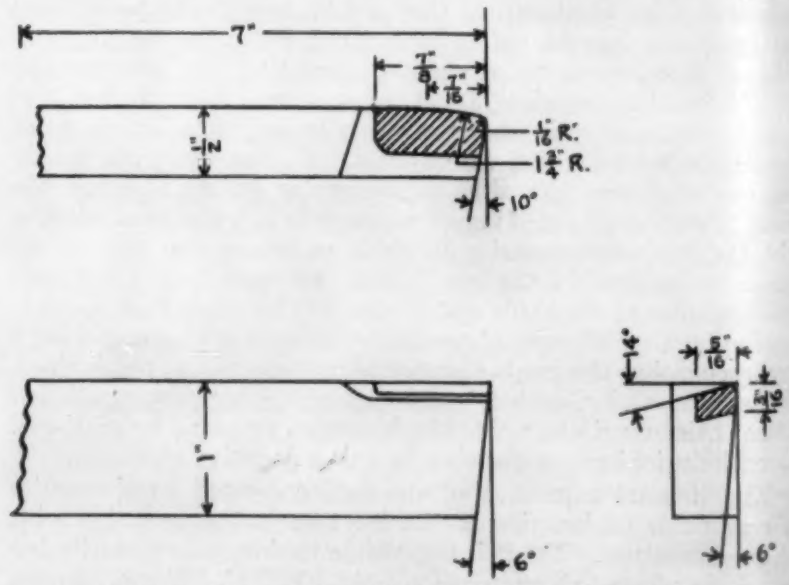


Fig. 2—Size and Form of Tool Used in Lathe Tests

Table 2
Chemical Composition, Heat Treatment and Average Mechanical Properties of the Forgings Cut in the Lathe Tests

Forging No.	Chemical Composition—%[1] C	Mn	P	S	Si	Ni	Cu	Heat Treatment[1]	Proportional Limit, lbs./in.²	Yield Point, lbs./in.²	Tensile Strength, lbs./in.²	Elongation in 2 Inches, %	Reduction of Area, %	Brinell Hardness Number
44	0.33	0.72	0.044	0.030	0.28	3.29	0.28	1480° F. held 1 1/2 hr.; furnace cooled. 1530° F. held 3 1/2 hr.; and cooled in emulsion[2]. 1200° F. held 3 1/2 hr.; furnace cooled.	81,500	86,500	106,500	26.0	61.3	230
45	0.29	0.65	0.032	0.029	0.32	3.40	0.26	1540° F. held 3 1/2 hr.; cooled in emulsion. 1220° F.—2 1/2 hr.; furnace cooled.	68,500	76,000	100,000	25.5	60.2	202
52	0.30	0.67	0.038	0.028	0.29	3.39	0.24	1520° F. held 3 1/2 hr.; furnace cooled.	59,000	60,000	88,800	29.0	53.1	168
53	0.30	0.61	0.026	0.037	0.26	3.43	0.24	1520° F. held 3 1/2 hr.; furnace cooled.	50,000	51,000	84,200	29.5	47.5	163
54	0.31	0.68	0.042	0.035	0.31	3.17	0.20	1500° F. held 3 1/2 hr.; furnace cooled.	51,500	54,000	85,200	31.0	55.0	163
55	0.30	0.67	0.034	0.033	0.29	3.37	0.22	1650° F. held 3 1/2 hr.; air cooled. 1480° F. held 3 1/2 hr.; furnace cooled.	58,000	60,250	95,250	30.5	51.8	180
56[3]	0.26	0.57	0.041	0.035	0.15	3.81	0.11	1650° F. cooled in emulsion; 1560° F. cooled in water; 1340° F. air cooled.	41,100	49,200	85,600	27.5	55.1	166

[1] Chemical composition and heat treatment data reported by manufacturer.
[2] The emulsion referred to consisted of 5% rape seed oil, 15% paraffin oil and 80% water containing 1% sodium carbonate.
[3] Forging No. 56 was hollow bored; hole approximately 5 1/2 inches in diameter. Nos. 44 and 45 were hollow bored; hole 4 inches in diameter.

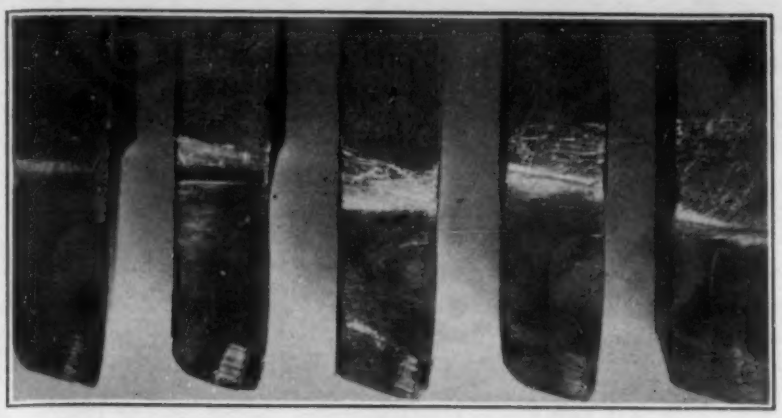


Fig. 3—Depressions Worn on Top Surface of the Tools during Tests. (All Tools Had Failed Except Tool Shown on Extreme Left.)

as the test progressed until a condition was finally reached when the wear was sufficient to cause a small section to chip or break out of the working portion of the tool. This 'end point' usually resulted in a glazed surface on the test forging and was often accompanied by a splitting of the chip which gave an additional indication of tool failure. Thus, there was a very definite end point and one that could be recognized without much difficulty. In some of the experiments, especially those of the most severe conditions of cutting, this end point was often

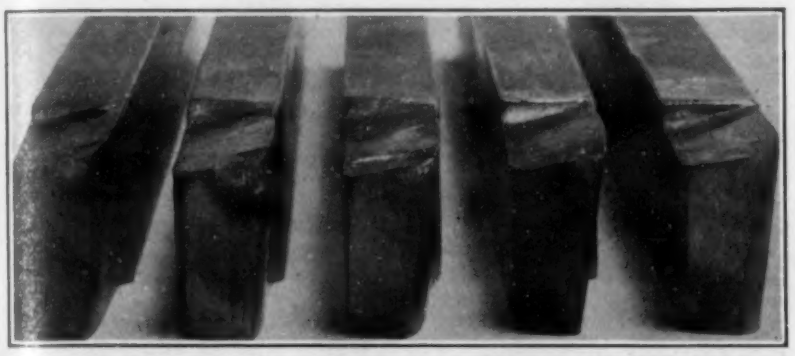


Fig. 4—Wear on Front of Tools during Test. (All Tools Had Failed Except Tool Shown on Extreme Left.)

quickly followed by, if not simultaneous with, tool breakage which would leave doubt as to the time of tool failure. Such doubtful tests were discarded in these experiments. In some cases it would have been possible to continue to cut after the described condition was reached but only at the expense of badly broken tools. All cutting results given in this report were obtained by the 'end point' method described. The wear on the top and front surfaces of the tools at the time of failure is illustrated in Figs. 3 and 4." This type of tool failure was also reflected on the surface of the test log by the appearance of a glaze which is shown in Fig. 5.

The first factor studied was the speed of cutting and its effect on the average tool life. During this series, the feed per revolution was held constant at 0.031 inch and the depth of cut at 0.1875 inch. The cutting speed was varied over a range corresponding to a tool life of 9 to 156 minutes. Within the limits of these tests and over this range of cutting speeds, the relationship between cutting speed and average tool life can be expressed by the following formula:

$$VT^n = c \qquad (1)$$

in which V = the cutting speed in feet per minute
T = the tool life in minutes
c = a constant which is dependent upon the cutting conditions other than speed. It should vary with the form and size of tools, material cut, nature of tools, feed and depth of cut.
n = constant.

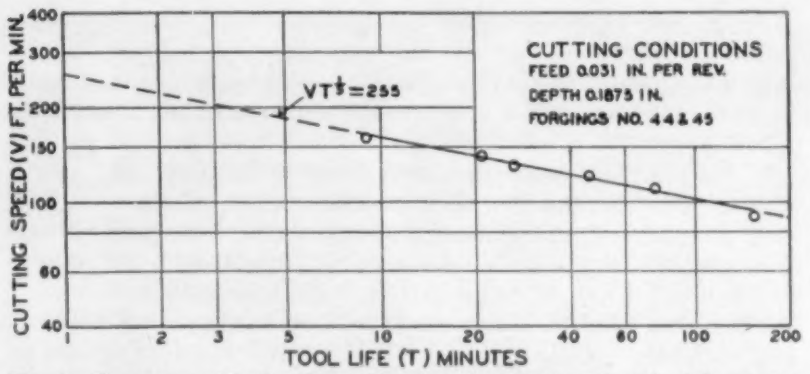


Fig. 6—Summary of Lathe Tests Showing that Cutting Speed of Cemented Tungsten Carbide Tools Varies Inversely as 1/8 Power of Their Life. (Tests Were Made "Dry" with Form and Size of Tool Shown in Fig. 2. Properties of Test Forgings Given in Table 2. Note That Logarithmic Coördinates Are Used.)

Numerically the constant "c" is the cutting speed corresponding to a tool life of 1 minute while the constant "n" gives the variation in tool life with cutting speed. This latter constant has been found to be about 1/7 for high speed steel lathe tools while the present investigation places this constant at 1/8 for cemented tungsten carbide with reasonable accuracy. It is convenient to represent this relationship graphically on logarithmic paper whereupon it takes the shape of a straight line. This is shown in Fig. 7. The slope of this line is numerically equal to the constant "n."

Besides establishing this relationship, this first series of tests showed that reliable data can be secured with cemented tungsten carbide tools as made by the (then) present state of the art. Having established this it was then in order to determine the effects of other factors on the tool life. In introducing this section of the paper, the author points out how the first results are utilized to reduce the time and expense of testing. "It is not practicable to select a single cutting speed for lathe tool testing varying widely in either feed or depth of cut because of the expense of the large amount of material that would be involved and the time required to make such a test. The cutting speed has already been shown to have an empirical relation to the tool life at a given feed and depth so that in the study of the effects of feed and depth on tool performance the cutting speed was also varied. In general, cutting speeds giving an average tool life from 10 to 30 minutes were selected and then the cutting speeds for the desired tool life were computed by means of equation 2."

Fig. 5—Appearance of Test Forging at Time of Tool Failure. (Note the Glaze at the Bottom of the Cut.)

$$VT^{1/8} = c \qquad (2)$$

"Two series of tests were made with the cemented tungsten carbide tools in order to estab-

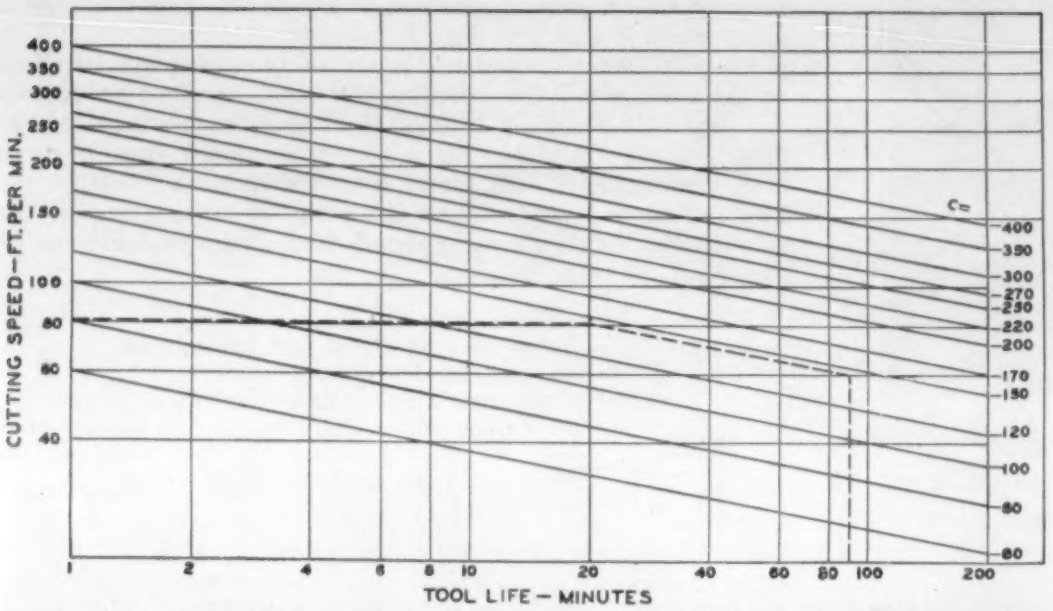


Fig. 7—Chart Giving Relation between Cutting Speed and Tool Life. (Lines Drawn According to Equation $VT^{1/4} = c$, in Which V = Cutting Speed, T = Tool Life, c = Constant.)

lish the relations between the cutting speed, feed and depth of cut. One was made with a constant depth of cut of 0.1875 inch and feeds ranging from 0.031 to 0.096 inch per revolution, and the other with a constant feed of 0.031 inch per revolution and depths of cut ranging from 0.125 to 0.5625 inch."

"The results of the tests made with a constant depth of cut and variable feeds are given in Table 4 and the cutting speeds for a 90 minute tool life with the different feeds used in the experiments are summarized in Fig. 8. As shown in Fig. 8, the relation between the cutting speed and the feed for a given tool life at a constant depth of cut, may be represented approximately by the relation

$$VF^m = c_1 \qquad (3)$$

in which V = cutting speed in feet per minute for a selected tool life
F = feed in inches per revolution
c_1 = constant
m = constant.

When operating with cutting speeds for a selected 90 minute tool life at a 0.1875 inch depth of cut in cutting 3.5% nickel steel forging having a tensile strength in the neighborhood of 85,000 lbs./in.^{2} the exponent, m, was found to be 0.58 with c_1 equal to 16.6. Substituting these results in equation 3, we have

$$VF^{0.58} = 16.6 \qquad (4)$$

The detailed results as recorded in Table 4 show a surprisingly close agreement between the individual tool performances. In a majority of the tests, this variation was no greater than that ordinarily found when testing high speed steel lathe tools under heavy duty."

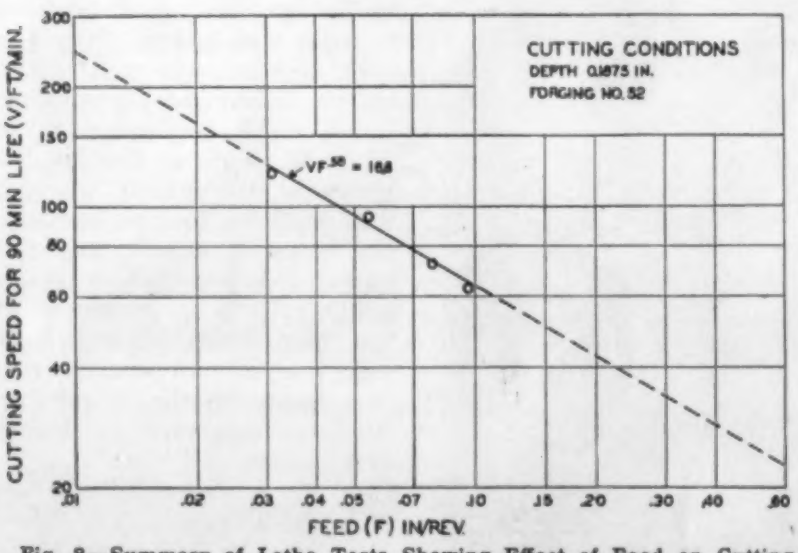


Fig. 8—Summary of Lathe Tests Showing Effect of Feed on Cutting Speed for a 90-Minute Tool Life. (Tests Were Made "Dry" with Form and Size of Tool Shown in Fig. 2. Properties of Forging Given in Table 2. Line Drawn According to Equation $VF^{0.58} = 16.6$, in which V = Cutting Speed for 90 Minute Tool Life in Feet per Minute, F = Feed, Inch per Revolution.)

"The results of the cutting tests made with a constant feed and variable depths are given in Table 5. The cutting speeds for a 90 minute tool life with the different depths used in the experiments are summarized in Fig. 9. The results show that there was a continuous increase in the cutting speed with decrease in depth of cut and that the relation between the cutting speed and depth of cut with a constant feed and given tool life may be represented by the equation

$$VD^p = c_2 \qquad (5)$$

in which V = cutting speed in feet per minute for a selected tool life
D = depth of cut in inches
c_2 = constant
p = constant.

'p' was found to be equal to 0.2 and 'c_2' was equal to 90, for a 90 minute tool life, and with a feed of 0.031 inch per revolution and depths of cut varying from 0.125 to 0.5625 inch. Substituting these results in equation 5, we have.

$$VD^{0.2} = 90 \qquad (6)$$

An examination of Fig. 9 shows that there was a close agreement between the experimental and calculated values over a wide range of depths of cut."

Summarizing, the author represents these relationships by Figs. 7 and 10 with which the speeds, depths of cut and feeds per revolution are correlated. These points are discussed in detail in the original paper.

After commenting on the desirability of extending such lathe tests to secure additional data, the author makes some pertinent comments under the heading "General Comments on the Lathe Tests." For example: "The heaviest cuts used with the 0.5 × 1 inch tools were probably greater than those that could be used in ordinary shop practice where cost, due to tool breakage, becomes important. The carbide tips of the tools were reduced in size by grinding and weakened accordingly so that most of the tool breakage was confined to the heaviest cuts with tools that had been reground. The test showed that the tools could be used under relatively heavy duty provided they were properly supported and not subjected to vibration."

"The forces on a lathe tool, while cutting, are practically independent of the cutting speed and are dependent upon the cross section of the chip.[1] It is evident from this principle that tungsten carbide tools should be used at relatively high speeds and for light cuts in order to keep tool breakage at a

[1] There is some evidence that this pressure falls off often at "super-high" cutting speeds.

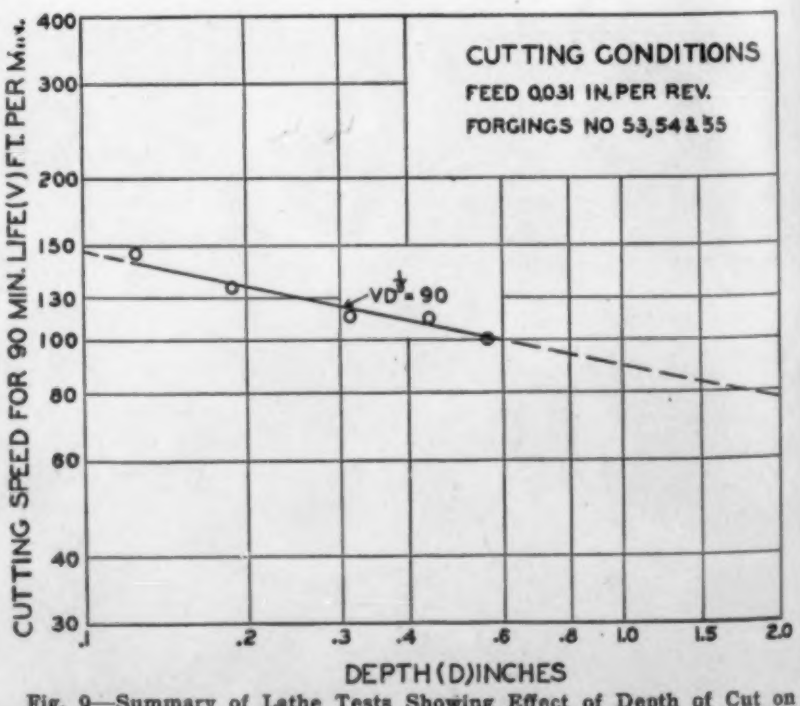


Fig. 9—Summary of Lathe Tests Showing Effect of Depth of Cut on Cutting Speed for a 90-Minute Tool Life. (Tests Were Made "Dry" with Form and Size of Tool Shown in Fig. 2. Properties of Forgings Given In Table 2. Line Drawn According to Equation $VD^{1/5} = 90$, in Which V = Cutting Speed for 90-Minute Life in Feet per Minute, D = Depth of Cut in Inches.)

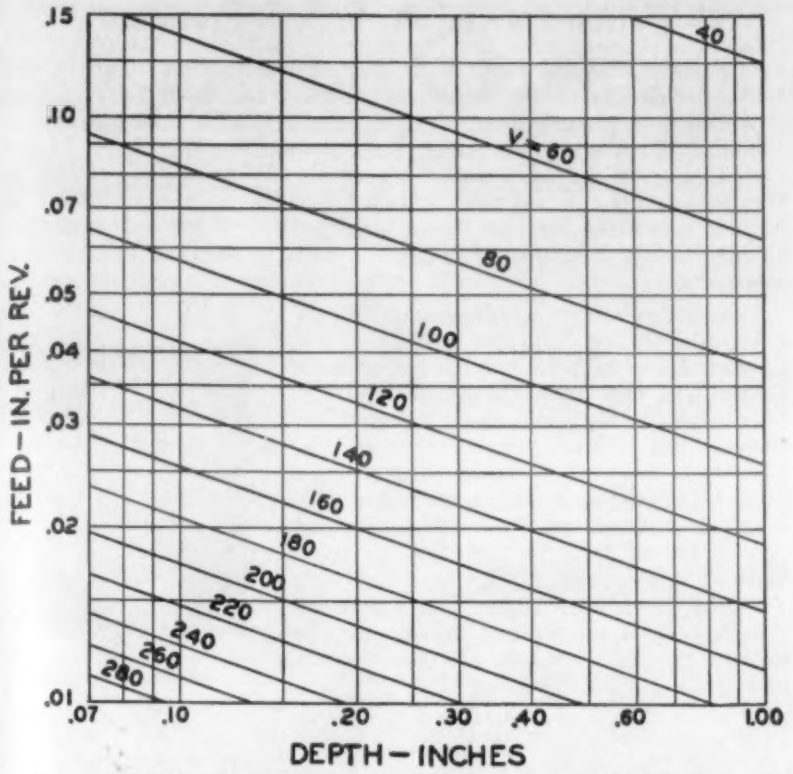


Fig. 10—Cutting Speed—Feed—Depth Chart for Selected Size, and Form of Tools and Cutting Material Used in Experiments. (This Gives Cutting Speed for 90-Minute Tool Life in Dry Turning 3.5% Nickel Steel of Approximately 85,000 Lbs./in.² Tensile Strength at Various Feeds and Depths. The Maximum Feed and Depth Values as Shown on Chart Are Greater Than Those That Can Be Used with 1/2 x 1 Inch Cemented Tungsten Carbide Tools.)

minimum. As shown by equation 2, the cutting speed varies as the 1/8 power of the tool life. This indicates that a small change in cutting speed causes a correspondingly large change in the tool life so that the higher cutting speeds are obtained only at the expense of shorter tool life. The most economical cutting conditions must, therefore, be a compromise between several factors such as, increase in cutting speed with decrease in tool life and tool breakage in order to remove the maximum amount of metal in the minimum time at the least cost."

Again an interesting comparison between cemented tungsten carbide and high speed steel is given in Fig. 11. These two plots show that the superiority of the former is greatest at the higher cutting speeds, or, more generally, under the more severe cutting conditions. If these laws of cutting were to hold down to very low cutting speeds, the life of the high speed steel tool would be greater than that of the cemented tungsten carbide tool. At present such an extrapolation from the experimental data would not be justified and this question must remain unanswered for the present. Mr. Digges wisely cautions against drawing too broad conclusions from the test results presented.

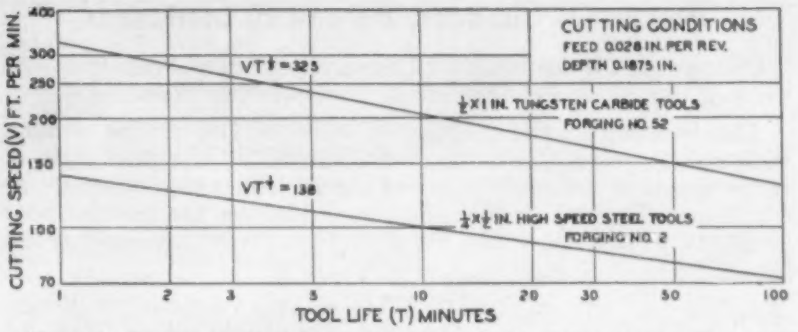


Fig. 11—Summary of Relation between Cutting Speed and Tool Life with Tungsten Carbide and High Speed Steel Lathe Tools. (Tests Were Run "Dry" with the Size and Form of Tools Shown in Report. Properties of Forgings Given in Table 2. For Cemented Tungsten Carbide Tools, Line Drawn According to Equation $VT^{1/8} = 325$. For High Speed Steel Tools Line Drawn According to Equation $VT^{1/7} = 138$, in Which V = Cutting Speed in Feet per Minute, T = Tool Life in Minutes.)

By way of supporting this, the reviewer would cite an early test in which a Carboloy tool cut for one hour without losing its cutting ability, while a corresponding high speed tool failed in 15 seconds. This order of superiority for cemented tungsten carbide tools under some cutting conditions is not brought out in the Bureau of Standards tests. On the other hand these tests also do not bring out the superiority of high speed steel under other cutting conditions, although in this case the economic relations generally are the controlling factors.

In conclusion Mr. Digges points out that though the power required in cutting was determined in all of the tests and at frequent intervals throughout the life of the tools, the exact relations between feed and depth and the power consumed cannot be obtained from the results recorded. "The power determinations are included with the test results in order to show that it is necessary to have machines equipped with powerful driving units in order to utilize the full capacity of tungsten carbide tools."

Mr. Digges has unquestionably made an excellent start in an almost virgin field, that of determining the inherent cutting ability of cemented tungsten carbide and the limitations within which this new tool material is to be used in industrial operations. Obviously considerable work still remains to be done and the work to date may be regarded as both the foundation and the justification for future work. Similar work has been done at the Experimental Station of Technische Hochschule, Charlottenburg, Berlin, Germany, and has been reported on in this country by the director, Dr. George Schlesinger. It goes without saying that engineers will await further reports from these two institutions with greatest interest.

In the work reported on by Mr. Digges, the Bureau of Standards was assisted by the Carboloy Company, Incorporated, of New York City.

Table 3
Effect of Speed on Performance of Cemented Tungsten Carbide Lathe Tools

Forging No.[2]	Cutting Conditions: Speed, ft./min.	Feed, in./rev.	Depth, inch	Number of Tests	Average Tool Life, min.	Calculated[1] Cutting Speed, ft./min.	Average Power Required in Cutting, k. w.
44 & 45	90	0.031	0.1875	5	155.9	93	4.1
44 & 45	110	0.031	0.1875	6	74.9	108	5.4
44 & 45	120	0.031	0.1875	6	45.9	119	5.5
44 & 45	130	0.031	0.1875	3	26.7	132	6.2
44 & 45	140	0.031	0.1875	6	21.2	139	6.4
44 & 45	160	0.031	0.1875	5	9.0	164	6.8

[1] Computed by means of equation $VT^n = C$ with $n = 1/8$ and $c = 255$.
[2] All tests were run dry with the size and form of tool shown in Fig. 3. See Table 2 for properties of forgings.

Table 5
Effect of Depth of Cut on Performance of Cemented Tungsten Carbide Lathe Tools

Forging No.[2]	Cutting Conditions: Speed, ft./min.	Feed, in./rev.	Depth, inch	Number of Tests	Average Tool Life, minutes	Average Power Required in Cutting, k. w.	Cutting Speed[1] for 90 Minutes Tool Life, ft./min.
53, 54, 55	200	0.031	1/8	8	17.7	5.7	144
53, 54, 55	180	0.031	9/16	8	15.1	7.2	126
53, 54, 55	160	0.031	5/16	8	14.4	11.8	111
53, 54, 55	150	0.031	7/16	7	18.5	16.6	109
53, 54, 55	140	0.031	9/16	7	16.5	20.6	100

[1] = Computed from the average tool life by means of equation $VT^{1/8} = C$.
[2] = See Table 2 for properties of forgings.
All tests were run dry with the size and form of tool shown in Fig. 3.

Table 4
Effect of Feed on Performance of Cemented Tungsten Carbide Lathe Tools

Forging No.[2]	Cutting Conditions: Speed, ft./min.	Feed, in./rev.	Depth, inch	Tool Life—Minutes: Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Average	Average Power Required in Cutting k. w.	Cutting[1] Speed for 90 Minute Tool Life, ft./min.
52	160	0.031	0.1875	30.6	11.5	21.2	20.8	20.8	27.3	25.0	22.5	5.5	121
52	120	0.054	0.1875	26.9	31.0	27.3	40.5	12.2	26.4	(b)	27.4	7.1	94
52	105	0.078	0.1875	23.3	8.0	12.1	16.0	(b)	12.7	12.6	14.1	8.5	72
52	90	0.096	0.1875	16.7	14.8	19.3	(b)	9.1	16.7	(b)	15.3	9.3	63

(b) = tool broke.
[1] = Computed from average tool life by means of equation $VT^{1/8} = C$.
[2] = See Table 2 for properties of forging.
All tests were run dry with the size and form of tool shown in Fig. 3.

Personnel Changes, Bureau of Standards

Changes in the leadership of some phases of the metallurgical work of the Bureau of Standards, have recently been made.

The vacancy in the position of chief of the section dealing with metallography, corrosion, etc., caused by the promotion of H. S. Rawdon, formerly chief of the section to be chief of the whole metallurgical division, has been filled by the appointment of Dr. D. J. McAdam, Jr., whose work on corrosion-fatigue has brought him wide renown.

Dr. D. J. McAdam, Jr.

Dr. McAdam was educated at Washington and Jefferson College. He did post graduate work in chemistry at Harvard and the University of Pennsylvania, and received his Ph.D. degree in chemistry from the latter institution. He was instructor in chemistry at Lehigh University from 1907 to 1910. Then, Dr. McAdam entered the Government service, and was employed as scientist in Soil Laboratory Investigations, Department of Agriculture from 1911 to 1913. From 1913 to September 30, 1930, he was metallurgist at the U. S. Naval Engineering Experiment Station, Annapolis, Md. He was then transferred to the Bureau of Standards, and was made chief of the section of metallography, division of metallurgy.

The recent resignation of Dr. R. L. Dowdell, to return to the University of Minnesota as professor of metallurgy, left a vacancy in the position of chief of the section of thermal metallography, which is concerned with heat-treatment, high temperature properties, etc. This has been filled by the transfer of Louis Jordan, formerly chief of the section on chemical metallurgy.

Louis Jordan

Mr. Jordan was educated at Bates College, Lewiston, Maine, and at the University of Illinois, receiving an M. A. degree in chemistry from the latter institution. He was connected with the Chicago Testing and Inspection Laboratory of Sears, Roebuck & Company, and with the Research Laboratory of the U. S. Industrial Alcohol Company before coming to the Bureau of Standards in 1917. For the past ten years, his work as chief of the section of chemical metallurgy has related chiefly to the preparation and properties of pure metals, the development of special refractories, and the development of methods for determining, and studies of, the influences of gases and inclusions in metals. The methods for determination of total oxygen, hydrogen and nitrogen in steel that were developed by Jordan and his co-workers are now recognized as the best available.

The vacancy occasioned by the transfer of Mr. Jordan has been filled by the appointment of Dr. J. G. Thompson as chief of the section of chemical metallurgy.

Dr. J. G. Thompson

J. G. Thompson received the degree of Doctor of Philosophy from Cornell University in 1920, in physical and electrochemistry. For nine months he was employed as chemist and metallurgist for C. B. Bohn Foundry Company, Detroit, makers of brass, bronze and aluminum castings. He was employed for four years in the chemistry division of the U. S. Bureau of Standards, doing research in physical and colloid chemistry. From there he went to the Fixed Nitrogen Research Laboratory Department of Agriculture, and spent four years in metallurgical work, corrosion and high temperature properties of structural metals. During the past year he was with the Cerro de Pasco Copper Corporation as the Bureau of Standards research associate on the extension of the uses of bismuth.

It is interesting to note that all these men were trained as chemists. The usefulness of a sound chemical training as a foundation for effective metallurgical work is well brought out by these appointments.

Watson Named A. S. S. T. President

Chicago, Illinois, September 27.—For the first time in the ten-year history of the American Society for Steel Treating, an automobile man has been elected president of the organization. He is J. M. Watson, metallurgical engineer for the Hupp Motor Car Corp., of Detroit and Cleveland. Watson's elevation to the presidency for the next year follows the routine in office, as he was treasurer for two years, vice president for one and thus automatically became president of this important engineering association.

Watson's election to office is indirectly a tribute to the firm he represents for it was the Hupp Motor Car Corporation's heat treatment plant in Jackson, Michigan, that was twice selected by the United States government as the locale of two industrial moving picture films to be shown to chemical and metallurgical students as the best illustrating this type of factory practice. Under Watson's supervision, the heat treating work of the Hupp Motor Car Corporation has been recognized as one of the most advanced leaders of the world's production of automobiles.

J. M. Watson

Is There a Demand for Standard Tests for Electroplated Coatings?

On June 24th at a regular meeting of Sub-Committee 7 Committee A-5 A. S. T. M., a small sub committee was appointed to determine the demand for new standard methods of testing metallic coatings for iron and steel. Inasmuch as the A. S. T. M. has already prepared methods of testing zinc, tin, and terne plate coated products, the coatings to be considered are the more common coatings applied by electro deposition such as cadmium, copper, nickel, chromium and possible combinations of these metals. Realizing that the preparation of such standards would entail a considerable amount of research work, the committee is highly desirous of ascertaining the existing demand for such standards, and the reactions of producers and consumers to the proposed standardization of existing test methods.

The committee has already circularized the membership of Committee A-5 of the American Society for Testing Materials, but is desirous of obtaining a broader reaction, and would appreciate the opinions of persons engaged in the production and consumption of metallic protective coatings.

Those interested should write to L. W. Hopkins, c/o Page Steel & Wire Company, Bridgeport, Conn., giving their opinion as to the desirability of developing standard methods as outlined above.

Oxweld Acetylene Company, 30 East 42nd St., New York, had introduced a new welding rod, designated Oxweld No. 23 Aluminum Rod, which is recommended for welding either aluminum sheet or castings when the metal is tightly held in jigs, and is not free to move.

At temperatures just below their melting point, aluminum casting alloys possess very little strength and have a high contraction coefficient. The combined effect of these two properties may under certain conditions cause cracks to occur adjacent to welds. The new welding rod is recommended for welding these alloys because of the fact that its melting point is lower than that of the metal being welded, so that it will remain in the molten state after the base metal has solidified. The weld metal will therefore fill in any voids that may have been created by the solidification and contraction of the base metal. Any stresses which might be caused by contraction will shift their effect from the base metal to the weld metal which, being free from hot shortness, will absorb the stresses without the development of cracks.

Oxweld No. 23 Aluminum Welding Rod coalesces readily with all of the aluminum alloys and possesses high strength and good corrosion resistance. It should always be used with Oxweld sheet aluminum flux.

The new aluminum rod is now available in three sizes, $1/16$ in., $1/8$ in. and $1/4$ in.

Current Metallurgical Literature Abstracts

These abstracts are not critical, but merely review developments as they are recorded. The various classifications are numbered. This number is at the end of each abstract and will be of assistance in mounting them on cards for filing.

GENERAL (0)

What the Buyer Should Know about Tin Plate. *Iron Age*, Vol. 125, April 10, 1930, pages 1066–1068.

Annual production of tin plate in the U. S. has grown from 500,000 net tons to almost 2,000,000 net tons constituting about 5% of total steel production. Outlines manufacturing process from the ore to the final packing of the tin plate. It is manufactured in about nine different grades, which are classified according to the weight of tin they carry. Coke tin plate carries about 1½–2½ lb. of tin per base box. Charcoal plate carries from 2½ to as much as 7 lb. per box. Amount of tin on the plate determines the grade. Composition of steel base and proper annealing are essentials of tin plate for drawing quality. Tin plate gages are expressed in lb. per base box. It should be ordered by base weight except gages No. 24 and heavier, which are sold by hundred-weight instead of base box. VSP(0)

Chemistry in the Telephone Industry. Robert R. Williams. (Bell Telephone Laboratories.) *Industrial & Engineering Chemistry*, Vol. 22, April 1930, pages 316–322.

The article presents some of the activities of the Chemical Department, among which are mentioned the fabrication of platinum-alloy vacuum-tube filaments and of new magnetic materials such as permalloy and perminvar: The dispersion hardening and fatigue resistance of lead and its alloys, the corrosion of cable systems, the tarnishing and corrosion of indoor telephone apparatus, metallic coatings as protective finishes, the production of solders, etc., are treated briefly. MEH(0)

Metallurgical Research from the Chemical Point of View. H. W. Gillett. (Battelle Memorial Institute.) *Industrial & Engineering Chemistry*, Vol. 22, March 1930, pages 232–240.

This is the outcome of a study of the research tendencies in this country and other countries and shows the relation of metallurgy to chemistry and the trend of research to centralization. MEH(0)

Progress in Steel Manufacture. L. K. Everitt. *Edgar Allen News*, Vol. 9, Aug. 1930, pages 669–672.

This first installment gives a short history of steel and includes an elementary discussion of modern quality tool steel. MLM(0)

Bridge Wire Requires Fine Steel. Frederick A. Westphal. (Sheffield Steel Corp.) *Iron Age*, Vol. 125, April 17, 1930, pages 1147–1153.

Discusses the processing from the billet through finished wire. Suggestions are given. The steel is made by either acid or basic open-hearth method. Acid steel appears more consistent in final physical tests. Scraps for steel of this nature should be shear scrap, crop ends or high grade melting scrap. Heats should not exceed 100 tons, and teeming should be at such speed as to prevent gas inclusion and bubbling. Ingot size to be 22 × 24 × 84 in., weighing 8800 lbs. Temperature not to exceed 2200° F. before blooming. Billet and weld mills should be carefully adjusted. Wire drawing schedule. VSP(0)

Non-Ferrous Metals and Alloys. II. George M. Enos. *Modern Machine Shop*, Vol. 2, Mar. 1930, pages 38–50, 102.

Brasses and bronzes are discussed from the viewpoint of their composition, constitution, heat treatment and uses. MLM(0)

Alloy Steels. John Johnston. *U. S. Steel Quarterly*, Autumn Number, 1930, pages 22, 25.

Alloy steels are defined and alloying elements briefly discussed. (0)

The Development of High Chromium and High Chromium-Nickel Alloys E. S. Mills. *U. S. Steel Quarterly*, Autumn Number, 1930, pages 34, 36.

Brief discussion. (0)

PROPERTIES OF METALS (1)

Tantalum (and Columbium). E. P. Youngman. *Information Circular*, 6328, August 1930, *United States Bureau of Mines*, 37 pages, 120 references.

Tantalum is described and discussed under the following headings: Physical, chemical and working properties; uses; history; minerals and their identification; extraction; production; sources of supply; imports and exports; consumption; prices; producers and buyers. AHE(1)

Cobalt. Paul M. Tyler. *Information Circular* 6331, August 1930, *United States Bureau of Mines*, 33 pages, 125 references.

Tyler gives a summary of information on the uses, occurrence, identification, metallurgy, production, imports and exports, foreign industry, prices and buyers of cobalt. AHE(1)

Total Radiation from Polished and from Soot-covered Nickel. B. T. Barnes. *Physical Review*, Vol. 34, Oct. 1, 1929, pages 1026–1030.

A study has been made of the total radiation obtained, at varying temperatures, from samples of polished nickel and of nickel covered with soot. Total emissivity values for the soot-covered nickel range from 0.92 at 400° K. (163° C.:325° F.) to a minimum value of 0.81 at 800° K. (527° C.: 980° F.) and rise subsequently to 0.86 at 1100° K. (863° C. : 1585° F.). In the case of polished nickel total emissivity at 1400° K. (1163° C. : 2225° F.) was found to be 0.205, while at 400° K. (163° C. : 325° F.) the values were 0.087 before heating to incandescence and 0.063 after undergoing this treatment. At intermediate temperatures similar differences occurred, due to surface changes during the initial heating. (1)

The Electromotive Behavior of Single Zinc Crystals. The Equilibrium Potential. Paul A. Anderson. *Journal American Chemical Society*, Vol. 52, March 1930, pages 1000–1008.

Examination of the electromotive characteristics of single metal crystals is suggested as a means of determining the relation of potentials to definitely describable surface structures and of contributing, thereby, to the study of the mechanism of electrode reactions and of the complementary problem of metallic surface structure. Single zinc crystals are found to behave as reversible electrodes; the (0001) cleavage face measured in air-free cells of type: Zn, $ZnCl_2$ (0.5 M), HgCl, Hg is capable of yielding potentials constant to ±0.02 millivolt and reproducible over dissimilarly prepared crystals to ±0.1 millivolt. MEH(1)

The Hardness of Hammered and Electrolytic Nickel. (Sur la dureté du nickel ecroui ou electrolytique.) Guichard, Clausmann, Billon & Lanthony. *Comptes Rendus*, Vol. 190, June 16, 1930, pages 1417–1419.

The gases which may be extracted from electrolytic nickel are H_2, CO and CO_2. They are present in only very small quantities. There is no systematic relation between the quantity of gas present and the hardness of the metal, hence the gases cannot be the cause of its great hardness. It is probably to be explained rather as due to the fineness of the crystals. The hardness of electrolytic nickel is not increased by hammering. (1)

The Supra-Conductivity of Metals and Alloys. (Ueber die Supraleitfähigkeit der Metalle und Legierungen.) A. Schulze. *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Feb. 1, 1930, pages 149–152.

After defining the expression "supra-conductivity" according to Kamerlingh-Onnes the micro-remainder resistance is that value which remains in a metal below a certain temperature; this value is for thallium $< 20 \times 10^{-10}$ at lower than 2.47° C. absolute, tin $< 6 \times 10^{-10}$ at 3.74°; mercury $< 2 \times 10^{-10}$ at 4.19° C., lead $< 0.5 \times 10^{-10}$ at 7.2° C. If, however, such supra-conductor is placed in a magnetic field this supra-conductivity disappears suddenly and the conductor assumes that resistance which it would possess in its ordinary state at the respective temperature and magnetic field strength. Purity of metal has no influence on this phenomenon. The author describes several investigations and series of experiments with many other metals and alloys which must be read in the original. The actual reason for supra-conductivity cannot yet be given a satisfactory explanation, but it is certain that it is a property of all conductors. Ha(1)

Uncommon Properties of a Common Metal. Robert M. Curts (New Jersey Zinc Co.). *American Machinist*, Vol. 72, Mar. 6, 1930, pages 413–415.

Rolled zinc works best at 70° F. or slightly higher. If a lubricant is required, soapy water is usually the cheapest and is quite satisfactory. Rolled zinc solders easily. Half solder is generally used. Zinc may be drawn, stamped, embossed, buffed or plated easily. Other metals may be plated on zinc but the use of nickel as a primary coat is advisable. The following is a suitable bath:

Single nickel salts	10 oz./gal. (75 gms./l.)
Anhydrous sodium sulphate	15 oz./gal. (113 gms./l.)
Ammonium chloride	1.75 oz./gal. (113 gms./l.)
Boric acid	2 oz./gal. (15 gms./l.)

Nickel coatings should be 0.0003 in. thick to be serviceable. RHP(1)

The Metal Crystal. Sir Harold Carpenter. *Engineer*, Vol. 149, June 6, 1930, page 641; *The Chemical News* (London), Vol. 141, Aug. 15, 1930, pages 97–103.

From paper read before the Royal Institution, May 30, 1930. Pure metals consist of a large number of allotriomorphic crystals. As ordinarily prepared, metals contain from one hundred thousand to several million crystals per cu. in. Author stresses importance of study of individual metal crystals. LFM(1)

Selenium and Tellurium. R. M. Santmyers. *Information Circular* 6317, July 1930, *United States Bureau of Mines*, 23 pages; *Canadian Mining Journal*, Vol 51, Aug. 22, 1930, pages 816–818.

A description is given of selenium and tellurium under the following headings: properties, uses, tests, history, occurrence, preparation, production and sales, imports and exports and market and prices. A bibliography of 43 references and 8 footnotes are given for selenium and 14 references and 7 footnotes for tellurium. WHB&AHE(1)

Gold—Its Present Available Quantity and a Novel View of Its Use. A. C. Young. *Canadian Mining Journal*, Vol. 51, June 27, 1930, pages 612–614.

Charts visualize the quantity of gold produced during the period of 1493–1927. The cubes, with linear dimensions noted, represent the world output during that period, production by continents, bank reserves (1927) consumed in the arts or lost, also Canada's and Ontario's gross production. A cu. ft. of gold weighs 1203.6 lbs. avoirdupois and has a value of $362,842.20. WHB(1)

Hardness of Electro-deposits. D. J. Macnaughton & A. W. Hothersall. (Research Department, Woolwich Arsenal.) *Electrical Review*, Vol. 106, April 11, 1930, page 711.

Extracts from a paper read before the Electroplaters' and Depositors' Technical Society. Used Brinell test for investigating hardness of deposits. Although in general, no great difference existed between the order of hardness of electrodeposited metals and that of the same metals produced by the usual metallurgical methods, there were certain exceptions. Cr deposits had a hardness equal to that of fully hardened alloy tool steels, yet Cr, prepared in pure form by metallurgical methods, has a hardness about the same as that of Cu. Ni metallurgically produced had a hardness of the order of that of mild steel, whereas the electrodeposited metal might have a much greater hardness. Suitable adjustment of the conditions of electrodeposition of a particular metal was of considerable importance in obtaining a wide range of hardness. Deposited metals fell into approximately the same order when classified according to their resistance to abrasion by emery as when arranged according to their Brinell hardness number. In the polishing process, for equal degrees of roughness, smoothing would be more difficult to effect in the case of a hard deposit owing to its greater resistance to plastic movement under pressure of the polishing wheel. Using identical depositing conditions it is possible to produce 2 well defined types of Ni deposit of widely different mechanical properties in 2 different types of solution. Hardness of Ni deposits depends on presence of NH_4 salts in the plating solution. MS(1)

Electrochemical Behavior and Velocity of Solution of Single Zinc Crystals. (Das elektrochemische Verhalten und die Auflösungsgeschwindigkeit von Zinkeinkristallen.) M. Straumanis. *Zeitschrift für physikalische Chemie*, Vol. 147, April 1930, pages 161–187.

Potential measurements with neutral and acid zinc sulphate solutions and determinations of the solution speed were carried out with single zinc crystals. The various crystallographic surfaces of a single Zn crystal show the same electromotive behavior in a neutral zinc sulphate solution, whereas the potential yields more positive values upon addition of acid. However, great fluctuations are noticed. The equation of Nernst does not hold true for this state. Saturation of the electrolyte with hydrogen causes more negative potentials, while oxygen exerts a reverse influence. Stirring results in a pronounced change in the potential. These phenomena are qualitatively explained by the assumption of a functional relation between potential and solution speed. Potential is a straight line function of velocity of solution for all crystal surfaces examined. The most negative potentials are found in case of absence of solution. The paper discusses the manner of solution of the various crystal surfaces by acid. EF(1)

PROPERTIES OF NON-FERROUS ALLOYS (2)

Silumin. Its Investigation, Characteristics and Technical Development. W. van Eichhorn. *Metallgesellschaft*, May 1930, pages 17–21; *Wärme und Kälte Technik*, Vol 32, April 20, 1930, pages 3–6.

Describes circumstances which led to the invention of Silumin (an aluminum-silicon alloy with some sodium), the properties of this new alloy, as well as a list of the uses to which it can be put. MLM(2)

Mechanical Properties of Aluminum Alloys for Castings Improved by Heat. T. W. Downes. (U. S. Naval Aircraft Factory.) *Automotive Industries*, Vol. 62, June 21, 1930, pages 944–949.

The article gives the best results of tests made of a series of aluminum-base specimens containing varying percentages of copper, silicon and magnesium. GN(2)

Silver Solders. R. H. Leach. *Preprint* 47, June 1930 Meeting, *American Society for Testing Materials*, 16 pages.

Compositions, melting points, flow points, tensile strengths, elongations, specific gravities and electrical conductivities of a wide range of Ag, Cu, Zn alloys used as solders are given, with some data on the effect of Cd additions. Other elements are usually detrimental. Nickel has some use. In most uses, malleability and ductility, as well as corrosion resistance, are important. Details are given of methods of use of the solders. Borax-boric acid fluxes are advised, and the fluidity of various mixtures at various temperatures is given. For soldering stainless steels or any alloy with much Cr, equal parts of borax and boric acid made into a paste with saturated zinc chloride solution is desirable. Proper solders and fluxes for joining brass, copper, nickel silver, stainless steels and irons, iron and steel, monel and nickel and aluminum bronze are mentioned. Special care is needed in heating monel in soldering. For special uses, special solders may be used. One melting at 480° F. and standing 50% reduction in cold working is 78.4% Cd, 16.6% Zn, 5% Ag. A very ductile one melting at 420° F. is 50% Sn, 30% Cd, 20% Ag. Sn-Zn-Ag solders melting at 650–860° F. and standing 50% reduction but with some edge-cracking, are mentioned. The ternary liquidus diagram for Cu-Zn-Ag alloys is given. HWG(2)

Light Metals in the Automotive Industry. Zay Jeffries. *Preprint* for March 1930 Meeting, *American Society for Testing Materials*, 14 pages.

See the extensive abstract of an earlier paper by the author on the subject "Light Alloys" which appeared in *Metals & Alloys*, Vol. 1, Dec. 1930, pages 267–270. See *Metals & Alloys*, March 1930, page 425. (2)

Duralumin Sheet. Proposed tentative specifications, in Report of Committee B-7, *Preprint* 23, June 1930 Meeting, *American Society for Testing Materials*, 3 pages.

Composition—Cu 3.5–4.5%, Mg 0.2–0.75%, Mn 0.4–1.0%, Al, min., 92%. Tensile properties—Annealed, 35,000 lbs./in.² tensile, 12% elongation for 2–20 B & S gage, 10% for 20–24 B & S and 8% for 24–28 B & S. Quenched and tempered, 55,000 lbs./in.² tensile, 30,000 yield point, 18% elongation in B & S 10–20 gages and 15% in B & S 2–10 and 20–28 gages. Cold bend tests for annealed material—180° around a pin of diameter 4 times the thickness of the sheet for 2–10 B & S gages, 2 times for 10–16, once for 16–20, flat on itself for 20–28. For quenched and tempered, 6 times the thickness for 2–10 B & S and 4 times for 10–28. HWG(2)

Bearing Bronzes with Additions of Zinc, Phosphorus, Nickel and Antimony. E. M. Staples, R. L. Dowdell & C. E. Eggenschwiler. *S. A. E. Journal*, Vol. 27, July 1930, pages 45–55; *Bureau of Standards Journal of Research*, Vol. 5, Aug. 1930, pages 349–364.

Seven basic copper-tin-lead bearing bronzes having high copper contents were studied by the application of various mechanical tests, such as Brinell hardness, resistance to impact, resistance to repeated pounding and resistance to wear. The effects of various additions were investigated by preparing test bearings of the same base alloys with additions of zinc, phosphorus, nickel and antimony, taken singly, and applying the same tests to these. The preparation of the test castings and the methods of testing are described in detail. The chemical analyses are given for the 40 different alloys tested; and the results of the various tests on each group of alloys are reported and discussed in detail, with the observations charted and tabulated for convenient reference. A tabulation of the specifications of 54 different bearing bronzes now in use is included in the paper. (2)

Seamless Copper Tubing—Tentative A.S.T.M. Specifications B-68-27 T. Proposed revision in report of Committee B5, *Preprint* 22, June 1930 Meeting, *American Society for Testing Materials*, 4 pages.

This specification had the former title, "Copper Tubing for Refrigerators," and is proposed to be changed to "Seamless Copper Tubing, Bright Annealed," to cover annealed copper tubing for refrigerators, oil and gasoline lines, etc., where tubing free from scale and dirt is required. The maximum phosphorus is lowered from 0.15 – 0.10%, copper minimum thus rising from 99.85 – 99.90%. Dimensional tolerances are revised. HWG(2)

PROPERTIES OF FERROUS ALLOYS (3)

Comparison of the Physical Properties of Different Sections of Cast Iron and of the Standard Arbitration Test Bar. M. V. Healey. Appendix to Report of A.S.T.M. Committee A-3 on Cast Iron, in *Preprint* 11, June 1930 Meeting, *American Society for Testing Materials*, 7 pages; *Engineering*, Vol. 130, Aug. 29, 1930, page 281.

A hollow box, cast in green sand with a dry sand core was made with one wall 4″ thick, one 2″, one 1″ and one nominally 1/2″, but actually, from the flexure-test table, 3/4″. Standard 1.3″ diameter arbitration bars were cast from the same metal, in dry sand. In the different sections total carbon ranged from 2.74 – 3.08%, combined, from 0.49 – 0.63%, silicon 1.95 – 2.19%, Mn 0.56%, P 0.37%. In flexure tests on 12″ supports, with bars 1″ wide by 4, 2, 1 and 3/4″ with 1″ dimension vertical, deflection ran from 0.165 – 0.19″ on the specimens from the casting, with no marked effect of size, while the arbitration bars gave 0.12″. The modulus of rupture of the 4″ thick section was 45,000 and for the thinner sections varied from 46,000 – 52,500 with no marked effect of size. Averages show decrease with size of section but individual figures for each size scatter over about the same range. The arbitration bars, however, gave 68,000. Tensile tests showed 32,000 for the arbitration bar and 23,500–30,000 for the castings with increase in strength as section diminished. The 1/2″ section was a trifle out of line, probably through insufficient feeding. Brinell tests showed 195 for the arbitration bar and 150–170 for the casting. Brinells showed fair correlation with strength. Micrographs are shown. LM+HWG(3)

Aluminum-Manganese Alloy Sheet. Proposed tentative specifications, in Report of Committee B-7, *Preprint* 23, June 1930 Meeting, *American Society for Testing Materials*, 3 pages.

Composition—1–1 1/2% Mn; Cu, max., 0.2%; Al, min., 97%. Tensile properties for hard temper—Tensile, B & S 10–20 gage, 27,000 lbs./in.²; 20–24 gage, 30,000; 24–28, 33,000. Elongation, 10–16 gage 4%; 16–20 gage 3%; 20–24 gage 2%; 24–28 gage 1%. For half-hard, tensile, all gages, 19,500 lbs./in.². Elongation, 2–16 gage 6%; 16–20,5 %; 20–24, 4%; 24–28, 3%. For soft tensile, all gages, 14,500 lbs./in.². Elongation, 2–16, 25%; 16–20, 23%; 20–28, 20%. Tensile specimens from half-hard to be cut in direction of rolling, other tempers in any direction. Bend test specimens, soft and half-hard, any direction. No bend test on hard. Cold bend test on soft temper 180° flat, on half-hard 180° around pin of diameter twice the thickness of the sheet. HWG(3)

Report of A.S.T.M. Committee A-1 on Steel. *Preprint* 9, June 1930 Meeting, *American Society for Testing Materials*, 9 pages.

Besides some definite proposals for new or altered specifications, subcommittees are working on the following: specification for intermediate manganese steel rails; study of proposals for new specifications for higher strength structural steel of the medium grade and revision of tensile strength for rivet steel; study of proposals for specifications for materials to be used at 1000° F. and 1500 lbs./in.², etc. HWG(3)

Malleable Castings. Report of Committee A-7, *Preprint* 15, June 1930 Meeting, *American Society for Testing Materials*, 2 pages.

Increase of the yield point requirement in specification A-47-27 for malleable castings from 30,000–32,500 lbs./in. is recommended for immediate adoption. HWG(3)

High Strength Cast Iron. E. J. Lowry. (Consulting Engineer, Detroit.) *Transactions, American Society for Steel Treating*, Vol. 17, April 1930, pages 538–562.

Paper presented before the Eleventh Annual Convention of the American Society for Steel Treating, September 1929. Includes discussion. The author points out that the greatest development in this line has been by European Investigators. Text-book information on the strength of cast iron is obsolete and unreliable. The author discusses the addition of such elements as nickel, chromium, molybdenum and vanadium. Alloy additions, however, are not a cure-all for cast iron deficiencies. A number of microphotographs and tables of physical properties are given illustrating the discussion of alloy additions. The discussion brought out the following factors as affecting the production of high strength cast iron, correct melting temperature, proper mixing in cupola, and correct mold pouring temperature and brought out the discrepancies between A.S.T.M. coupon tensile tests and tests made on lugs attached to the castings themselves. See *Metals & Alloys*, Vol. 1, Jan. 1930, page 337. WLC(3)

Austenitic Manganese Steel Castings. Proposed tentative specification in *Preprint* 9, *Report of American Society for Testing Materials Committee A-1 on Steel*, June 1930 Meeting, 4 pages.

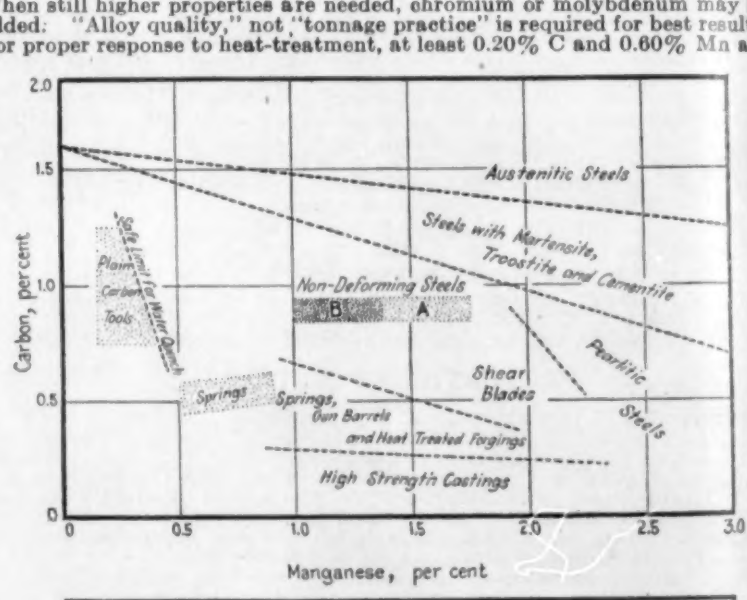
Open-hearth, electric, converter or crucible melting is permitted. Composition, carbon 1–1.4%, manganese 10–14%, phosphorus not over 0.10% in melt analyses. For individual castings carbon may run 0.9–1.5% and phosphorus to 0.11%. Annealing for several hours at 500–600° C. before drilling for analyses is recommended. Castings may be tested to destruction if they weigh less than 50 lbs. Destruction shall be by pressure or blows and must "show the casting to be tough and ductile." Bend tests are made on separately cast 1/2 × 3/4 × 12″ specimens which must bend cold 150° around a 1″ diameter pin. Castings and bend specimens are to be heated to at least 1000° C. "until they are uniformly heated throughout," and quenched in water. HWG(3)

The Highly-Alloyed Steels in Aircraft Construction. J. Strauss. In *Preprint* 33a, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 7 pages; *Engineering*, Vol. 130, Aug. 29, 1930, page 282.

Discusses Cr Si valve steels, stainless iron, free-turning stainless iron, stainless steel and the higher C, higher Cr steels like 0.60% C, 16 1/2% Cr; 1.1% C, 17% Cr, 1% Si; 1.3% C, 12% Cr, 3 1/2% Co, 3/4% Mo; austenitic steels of the 18% Cr, 8% Ni type and the modifications with additions of Si and W, and with higher Ni and Cr. Drawbacks and advantages are noted. LM+HWG(3)

The New Manganese Alloy Steels. E. E. Thum. *Preprint* 34, June 1930 Meeting, *American Society for Testing Materials*, 22 pages

General résumé of properties of and applications for steels ranging from about 0.15%–2% C and 0.50–2% Mn. In replacement of carbon steels, the carbon content must be dropped as the manganese is raised. With due attention to this precaution the medium manganese steels compete with other alloy steels. The steels tend to be clean, to work easily, the scrap contains no element that would contaminate tonnage steel heats and the cost is low. When still higher properties are needed, chromium or molybdenum may be added. "Alloy quality," not "tonnage practice" is required for best results. For proper response to heat-treatment, at least 0.20% C and 0.60% Mn are



needed, in properly deoxidized steels. Endurance limits of normalized structural plates are given. With 0.18–0.29% C and 0.36–1.60% C these are, as usual, half the tensile strength, but with a 0.50% C, 0.68% Mn steel, the ratio is lower, and in a slightly cold worked low C, low Mn steel finished below the transformation range the ratio is only 40%. Applications cited are rails, structural, bridge and ship steels, boiler plate, tubing, gas cylinders, high strength steel castings, welding rod, steel for carburising, heat-treated forgings, auto frames, springs, shear blades, "small-deforming" steels, etc. The C-Mn ratio for steels for various uses are shown in the figures. HWG(3)

Rational Choice of Tool Steels. JAMES P. GILL. (Vanadium Alloys Steel Co.) *Iron Age*, Vol. 125, March 13, 1930, pages 782–785.

From paper delivered before the New York, and the New Jersey chapters of the American Society for Steel Treating. There are three groups of alloying elements used, depending whether element is dissolved by the iron, combines with carbon to form carbide or partly dissolved by the iron and partly forms carbide. Elements dissolved by iron increase strength and toughness of steel. Those forming carbides increase hardness. While elements partially dissolved by iron also forming carbides increase toughness and hardness. Varying the quantity and proportion of alloys a number of steels having different physical properties can be produced. Tabulates approximate composition and properties of 14 types of tool steels commonly used. For blanking dies steels such as Mo, non-deforming type containing 1.25% C and 2% Mo, high C-Cr type and high-speed steels are used. For forming dies used wholly for forming cold material C or C-Va steels are preferred. VSP(3)

The Relative Merits of Some Different Alloy Steels with Respect to Certain Mechanical Properties. B. STOUGHTON & W. E. HARVEY. *Preprint*. 35, June 1930 Meeting, *American Society for Testing Materials*, 17 pages; *Engineering*, Vol. 130, Aug. 29, 1930, page 280.

Study of data in the literature by application of various "quality factors," such as tensile times elongation, elastic limit times reduction of area, tensile times Izod, etc., etc., in an effort to find a quality factor that will pick out superior steels. The data are tabulated in various ways. In one classification such widely varying compositions as 0.47% C, 0.51% Cr and 0.09% C, 16.0% Cr are classed together as chromium steels. Variations in methods of testing for elastic limit, in notches used on Izod bars, etc., in size of bar from which test specimen was taken, whether heat-treated in test bar or larger size, etc., are not given and these variations probably affect the tabulations. No attention is paid in quality factors employed, to cleanliness of steel, ease of rolling, response to heat-treatment, depth hardening, weldability, machinability or cost, though attention is called to the fact that some of these are important. A large amount of data is recorded on Ni, Ni Cr and Cr V steels of tensile strengths from 100,000 to 300,000 lbs./in.^{2} with references to the original sources of the data. No conclusions are drawn as to which, if any, "quality factor" is to be preferred. The discussion is merely presented as "food for thought."
LM+HWG(3)

CORROSION, EROSION, OXIDATION, PASSIVITY AND PROTECTION OF METALS AND ALLOYS (4)

Corrosion Problems in the Rayon Industry. PERCY C. KINGSBURY. (General Ceramics Company.) *Industrial & Engineering Chemistry*, Vol. 22, Feb. 1930, pages 130–132.

Presented at the meeting of the American Institute of Chemical Engineers, Asheville, N. C., Dec. 1929. Attention is drawn to the practical utility of using stoneware for storing muriatic acid and other corrosive materials.
MEH(4)

Non Corrosive Steels in Chemical Industry. (Contribution a l'etude des aciers inattaquables pour l'industrie chimique.) J. POMEY & P. VOULET. *Revue de Metallurgie*, Vol. 27, June 1930, pages 334–335; *Chimie & Industrie, Special Issue*, March 1930, pages 212–226.

An abstract of the paper delivered at Barcelona Meeting of the Congress of Industrial Chemistry. The study of Fe–Cr–Ni–W system permitted the authors to produce complete austenitization of Ni–Cr alloys by addition of a few percent of Si, Mo and W. Alloys were compared on the basis of corrosion resistance to aqueous solutions. The additions decrease it. Some constituents of steel cannot enter the solution as metallic ions and deposit on the surface as oxides. They retain the metallic ions by absorption. The presence of the coating and an electrical field created minimizes the chemical properties of the layer which is of a high stability. The absence of corrosion requires an equipotential surface. JDG(4)

Metallic Friction and Oxidation. *Engineering*, Vol. 130, July 4, 1930, page 29.

Consists mainly of comments on a dissertation by Max Fink entitled "Neue Ergebnisse auf dem Gebiet der Verschleissforschung." Recent work by several other investigators is briefly discussed. G. A. Tomlinson several years ago investigated pivot friction at the National Physical Laboratory. He observed that steel plates held in contact would rust on the common surfaces when agitated and oiling did not prevent this rusting. No oxidation would occur unless particles were detached by tangential stress. Thus there would be no oxidation with pure rolling friction unless slipping occurred. Dr. Fink disagrees with this conclusion. His experiments are briefly described. He shows that no metal would be abraded if oxygen could be rigorously excluded. Krupp V2A steel which is not oxidizable at relatively high temperatures, oxidized easily in these tests. Dr. Fink considers that during the running-in period, the initial small areas in actual contact become coated with a protective oxidized film which gradually spreads. At the same time, the pressure, first concentrated on the few spots, is distributed over a larger surface, and the friction moment decreases. LFM(4)

Corrosion of Structural Steel and Steel Reinforcing Rods Encased in Concrete. E. A. CROSS. *Engineering*, Vol. 130, July 4, 1930, page 30.

Describes corrosion which occurred in the structural steel of the engine room floor of a department store in Toronto, Canada. The concrete floor had cracked in several places in the vicinity of a leaking refrigeration brine tank. Steam mains were leaking in the pump room below the engine room. All these factors were considered responsible for the corrosion of the steel-beams. Reinforcing rods were corroded away to a tapering point. Describes repairs which were made. LFM(4)

The Open-Air Corrosion of Copper. Part II.—The Mineralogical Relationships of Corrosion Products. W. H. J. VERNON & L. WHITBY. (Chemical Research Laboratory, Teddington.) *Institute of Metals, Advance Copy* No. 542 (1930), 8 pages.

The chemical compositions of patina on copper reported in the first paper are reconsidered and it is found that in the older samples definite minerals are formed. The copper sulphate patina corresponds to the mineral brochantite, $CuSO_4.3Cu(OH)_2$, the chloride to atacamite, $CuCl_2.3Cu(OH)_2$, and the carbonate to malachite, $CuCO_3.Cu(OH)_2$. Complete agreement with the mineralogical composition was realized only after exposure of seventy years or more. In urban exposures the black, cuprous sulphide, chalcocite, is probably formed and later oxidized to the blue cupric sulphide, covelite. Contains 6 references. See abstract of Part I in *Metals & Alloys*, Jan. 1930, page 339. JLG(4)

Deterioration of Structure in Sea-Water. *Iron & Coal Trades Review*, Vol. 120, April 11, 1930, page 597.

Abstract of the report of the committee of the Institution of Civil Engineers. Issued as the Tenth (Interim) Report of the Department of Scientific and Industrial Research. Four test bars of 13.57% chromium steel were severely pitted by sea water. Tensile test specimens were machined from bars exposed to complete immersion in the sea for 5 years. Tests show that the exposure has had no appreciable effect on the properties of metals. Various types of paints and other protective coatings are being tested on samples of mild steel. Pitting was less with the iron-oxide paints than with the lead paints. In most cases tar yielded better results than the standard paint. RHP(4)

Galvanic Corrosion on Cast-Pipes. R. J. KUHN. (New Orleans Public Service, Inc.). *Industrial & Engineering Chemistry*, Vol. 22, April 1930, pages 335–341.

This type of corrosion of underground pipe has been successfully counteracted by electrolysis drainage, or the connection of underground metallic structures to the negative busses of railway substations. It is claimed that the drainage causes a collection of current which counteracts the discharging galvanic currents. MEH(4)

Corrosion of Steel by Atmospheric Influences. J. S. UNGER. *U. S. Steel Quarterly, Autumn Number*, 1930, pages 45, 47, 48, 51.

Paper describes tests comparing plain carbon and copper bearing steels applied to gondola and hopper railroad cars. After 13 years service the average loss of the 2 kinds of steel was as follows:

	Loss % Plain O. H.	Copper-Steel
Gondolas–Side Sheets	36	12
Hoppers—Outside Hopper Sheets	57	32 (4)

1930 Corrosion Review. F. N. SPELLER. *U. S. Steel Quarterly*, Apr.-June, 1930, pages 72–74.

Review of developments resulting from recent corrosion investigations. (4)

The Theory of Passivity. (Bemerkungen zur Diskussion über die Passivitätstheorie.) R. MUELLER. *Zeitschrift für Elektrochemie*, Vol. 35, July 1929, pages 459–460.

A review of the theories of passivity. (4)

Tanker Construction and Corrosion. *Engineering*, Vol. 130, July 25, 1930, pages 112–113.

Editorial. Briefly traces history of tanker construction. Tankers used for carrying light oil are particularly liable to corrosion. Weight and impact of cargo are borne by rivets and not by framework. Corrosion sets in due to this high stress. Recommends reduction in area and number of parts exposed to corrosion. Vessels can be diverted for a time to the heavy oil trade. Refers to a paper read recently by John McGovern at the joint meeting of the North-East Coast Institution of Engineers and Shipbuilders and the Institution of Engineers and Shipbuilders in Scotland. LFM(4)

Corrosion of Steel Freight Cars. P. P. BARTHELEMY. *Railway Mechanical Engineer*, Vol. 104, July 1930, pages 393–396.

Some practical suggestions are advanced regarding effective corrosion-prevention methods. GN(4)

Cast Iron with Nickel, Copper and Chromium. *Iron Age*, Vol. 125, April 24, 1930, page 1216.

Brief abstract translation of article in Oct. 1929, issue of *Revue de Métallurgie*. See *Metals & Alloys*, Feb. 1930, page 384, "A Study of Some Cast Irons Containing Nickel and Copper" by M. Ballay. VSP(4)

The Use of Steel in the Oil Industry with a Special Reference to Heat-Resisting Steels. R. HADFIELD & S. A. MAIN. *Journal Institution of Petroleum Technologists*, Vol. 15, Oct. 1929, pages 611–633.

Discusses importance of using best steel in oil-well drilling and pumping. Gives a review of the manufacturing of heat-resisting and non-corrodible steels. (4)

The Corrosion of Steel by Breeze and Clinker Concretes. F. L. BRADY. *Department of Scientific & Industrial Research, Building Research, Special Report* 15, 15 pages, price 6d.

The factors, which might influence corrosion are considered: porosity and permeability; unsoundness; soluble salts; and moisture adsorption. The previous work is reviewed, and the results of the new series of tests are given. (4)

Corrosion-Resisting Steel and Its Application to Ships. HAROLD E. SAUNDERS. (U. S. Navy.) *Engineering* (London), Vol. 129, Feb. 21, 1930, page 263; *Marine Engineering & Shipping Age*, Vol. 34, Dec. 1929, page 682.

Short abstract of paper read before the American Society of Naval Architects and Marine Engineers, Nov. 14–15, 1929, 21 pages. LM(4)

Particle Size as a Factor in the Corrosion of Lead by Soils. R. M. BURNS & D. J. SALLEY. (Bell Telephone Laboratories). *Industrial & Engineering Chemistry*, Vol. 22, March 1930, pages 293–297.

It has been shown that lead is corroded by contact with moist inert sands in the presence of air, and that the rate of attack is increased by increasing within certain limits the particle size of the sand, the moisture content of the sand and the oxygen content of the atmosphere. Corrosion is caused by oxygen concentration cells which are set up as a result of the partial or complete exclusion of oxygen at the points of contact of metal and soil.
MEH(4)

A Study of Ancient Bronzes. G. ZENGHELIS. *Chimie et Industrie*, Vol. 23, Mar. 1930, pages 556–563.

The "patina" or scale on ancient Greek bronzes was in some cases deliberately produced by the sculptor by heating and exposure to vapors containing H_2S. Corrosive scale, or so-called "bronze disease," consists of a mixture of oxychlorides and carbonates, and is of electrolytic origin; it cannot exist in bronzes beneath the sea owing to the absence of O and especially of CO_2. Newly recovered bronzes should be tested for liability to this "disease" by keeping 2 days in an atmosphere saturated with water vapor; if a green scale develops, the bronze can be protected by treating by the Rozenberg method, in which Cl is removed by applying Al foil by means of a paste consisting of glycerol and agar-agar. (4)

Overhead-Line Corrosion. G. W. MOLLE. *Electrical Review*, Vol. 106, June 13, 1930, pages 1132–1133.

Includes discussion. Abstract of paper read before the Overhead Lines Association. Discusses modern theories, recent research and the trend of metallurgical developments. Cu-steel is being used for the transmission-line towers of the Central-England electricity scheme. Galvanized steel towers have a life of 14–50 years, depending upon local conditions and the excellence of the coating. Painting is more efficacious in a very bad industrial atmosphere. Deterioration of high-tension line conductors at one time attributed to HNO_3 formed by corona, is now attributed to vibration. Cd and Cr plating and stainless are coming into use for outdoor switch-gear. It is claimed that metal-spraying gives better adhesion and more uniform coating than galvanising. Porcelain insulators are being sprayed with Zn, Sn or Cu to prevent corona. Sherardizing is another important coating process from the overhead-line point of view. Stay wires and stay rods should be heavily galvanized and also painted with bituminous paint near the ground. All metal below ground should be adequately protected against corrosion. Best practice is to use earth plates of considerable thickness and sink them 7–8 ft. deep, protecting the connecting wire against corrosion. MS(4)

Corrosion Phenomena on a Cast Iron Service Line Under the Influence of Mineral Waters. (Korrosionserscheinungen an einer Gusseisenmuffenrohrleitung unter dem Einfluss vagabundierender Mineralwässer.) F. ENSZLIN & FR. BUSCHENDORFF. (Bergakademie Clausthal.) *Korrosion & Metallschutz*, Vol. 5, Oct. 1929, pages 227–230.

Failure in service of a cast iron soil pipe corroded at a joint which contained lead packing material was observed. A layer of incrusted mineral matter was found at the outside surface whereas the inside was almost unaffected. The corrosion is attributed to the influence of the ground water high in mineral content and due to the electrolytic action of the local element Fe-Pb in the mineral water at the joint. EF(4)

STRUCTURE OF METALS AND ALLOYS (5)

Metallography and Macrography (5a)

A Heuristic Theory of the Structure of Steel. LEON CAMMEN (Consulting Metallurgist). *Transactions, American Society for Steel Treating*, Vol. 17, April 1930, pages 563–569.

The author presents a new theory of the structure of steel in which the amorphous cement or intergranular material of steel is presumed to be a crystalline material of extreme fineness (too fine to be seen with the most powerful microscopes of to-day). He points out other materials such as rubber which until recently were supposed to be amorphous but which are now recognized to be crystalline. The tensile failure of steel is through the large visible grains which means that the intergranular material itself and its bond with the larger grains are stronger than the grains. Amorphous materials while inherently strong under compression are weaker toward tensile stresses and shock than crystalline materials. The theory of a crystalline intergranular matrix of very fine crystals allows a simpler explanation of grain or crystal growth than the amorphous cement hypothesis. WLC(5a)

On the Lowering of Critical Points in Molybdenum Steels. TAKEJIRO MURAKAMI & TAKESHI TAKEI. *Science Reports Tohoku Imperial University*, Vol. 19, May 1930, pages 175–207.

The fact that the critical points in certain molybdenum steels are lowered in steps as the maximum heating temperature exceeds a certain point, is already well known. In the present work, the conditions affecting the lowering were thoroughly studied, by utilizing magnetic analysis and the dilatometric method for molybdenum steels containing 0–0.70% Mo and 0–0.6% C and demonstrated that the lowering depends also on the rate of cooling and the composition of alloys, besides the maximum heating temperature. The effect of the rate of cooling on the lowering of critical points is similar to that of the maximum heating temperature; that is, the critical point is lowered in steps, as the rate of cooling increases; the lowering is, however, markedly affected on the rate of cooling through the normal critical point, though the effect of the rate above the point is practically nil. The composition range of alloys in which the lowering takes place differs with the cooling additions. The range was shown in diagrams for respective conditions; in alloys near the eutectoid composition, the lowering readily takes place. The microstructure of alloys cooled under various conditions was also studied and demonstrated that in alloys in which the lowering takes place, acicular ferrite is always observable and that the higher the maximum temperature and the slower the rate of cooling is, the coarser the structure. From the results, the cause of the stepped lowering of critical points and formation of the acicular ferrite were satisfactorily explained, assuming the rate of crystallization curves for respective constituents, i. e., ferrite, carbide and martensite. (5a)

Metallography of Zinc-Base Die Casting Alloys. W. M. PIERCE. Appendix to Report of Sub-Committee XV of Committee B-2, in *Preprint* 19, June 1930 Meeting, *American Society for Testing Materials*, 2 pages.

The 4% Al, 3% Cu, zinc-base die casting alloy as cast, consists, as to the Zn and Al, of an eutectic of α and β constituents plus excess α. At 270° C. β transforms rapidly to α and γ. Cu and Mg slow up the rate of transformation. It occurs, however, at room temperature very slowly, taking years to complete it, or a few days at 100°. The change is accompanied by decrease in volume (in the data of the sub-committee report the dimensional change is given as an expansion in length, abstractor), marked decrease in impact resistance and elongation and slight decrease in tensile strength. This is not due to corrosion but to a structural change, which is reversible. Heat treating to produce the change initially is being studied. but may not produce the same properties as long aging at room temperature. HWG(5a)

Magnesium-Manganese Alloys. G. W. PEARSON. *Industrial & Engineering Chemistry*, Vol. 22, April 1930, pages 367–370.

Study of the microstructures of magnesium-manganese alloys shows that the solid solution area extends beyond 2.7% manganese. In the higher ranges that metal may show up as angular masses. In the still higher ranges, 35% and up to pure manganese, it appears as irregular masses in a background of magnesium. MEH(5a)

Investigations on Individual Crystals of Copper and Brass. (Untersuchungen an Einzelkristallen aus Kupfer und Messing.) J. WEERTS. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Nov. 16, 1929, pages 1644–1646.

A review of results obtained by other investigators; cannot be described in detail, the original article must be referred to. Ha(5a)

The Diffusion of Aluminium into Iron. N. W. AGEEW (Polytechnical Institute, Leningrad) & OLGA I. VHER (Institute of Metals, U. S. S. R.). *Institute of Metals, Advance Copy* No. 536 (1930), 13 pages, 17 references.

The iron–aluminum system is reviewed and a carefully drawn equilibrium diagram shown. The diffusion of aluminum into iron at a temperature of 1100° C. was studied by means of microscopic examination and chemical analyses. It was found that the reaction of molten aluminum with iron takes place in 2 steps: (*a*) Dissolution of iron in liquid aluminum with the formation of a solution in equilibrium with the solid phase. (*b*) Diffusion of the alloy so formed into the iron. The carbon does not diffuse into the aluminum and is concentrated in the iron phase near the solid aluminum-iron phase. The nature of the products formed were in complete agreement with the diagram given. The rate of diffusion was determined and the relationship proposed by Weiss confirmed. The rate of diffusion falls rapidly with the time of treatment. JLG(5a)

Graphitization of Prequenched White Cast Iron. H. A. SCHWARTZ, H. H. JOHNSON & C. H. JUNGE. *Transactions American Society for Steel Treating*, Vol. 17, Mar. 1930, pages 383–409.

Includes discussion. A study of the acceleration of graphitization produced by the prequenching of the hard iron before annealing. The progress of graphitization with time at different temperatures is shown in a series of curves, and theoretical equations based upon an assumed geometry of the cementite grains and upon the relative rates of precipitation and diffusion of graphite are compared with the experimental curves. According to the theory the graphitization reactions are interfacial in character, diffusion rate not being a controlling factor since this is accelerated by the presence of more nuclei due to the prequenching. It is stated that the "percarbides" found by the electrolytic method of analysis were probably formed during the analysis itself, a result which is confirmed in the discussion. Indications were found that there may be a need for a new line in the iron-carbon diagram (metastable) starting at 6.67% C. and below the A_1 point, curving upward toward the left and ending at the eutectic melting point, the solid phase to the right of this line being a solid solution of γ-iron in cementite. In the discussion the relative frequency of occurrence of graphite nuclei in cementite and pearlitic areas is taken up. WHK(5a)

A Note on the Constitution of the Cadmium-Zinc Alloys. D. STOCKDALE. (King's College, Cambridge.) *Institute of Metals, Advance Copy* No. 537 (1930), 6 pages, 5 references.

Both the zinc-rich and cadmium-rich portions of the diagram were redetermined. The results were substantially in agreement with those reported by Jenkins in the *Journal of the Institute of Metals*, Vol. 36 (1926), page 63. An allotropic change was observed in zinc and possibly in cadmium. JLG(5a)

On the Ternary System Iron–Nickel–Sulphur. (Ueber das Ternäre System Eisen-Nickel-Schwefel.) R. VOGEL & W. TONN. *Archiv für Eisenhüttenwesen*, Vol. 3, June 1930, pages 769–780; *Stahl und Eisen*, Vol. 50, July 31, 1930, pages 1090–1091.

The area iron–nickel–nickel sulphide–iron sulphide of the ternary diagram iron–nickel–sulphur was studied. The system iron–nickel is characterized by a group of solid solutions, the system iron–iron sulphide by a eutectic at 985° C., the system iron sulphide–nickel sulphide (Ni_3S_2) by a ternary compound $(FeS)_2Ni_3S_2$ which is in equilibrium on the one hand with iron sulphide below 885° C. and which on the other hand forms a complete group of solid solutions. In the system nickel sulphide–nickel, nickel forms at 645° C. a eutectic with a nickel rich solid solution of nickel suphide. The transformation of Ni_3S_2 at 530° C. leads to a eutectic decomposition of the solid solutions into pure Ni_3S_2 and Ni. On this basis the mentioned ternary diagram was established by thermal analysis and microscopic investigations. Besides the compound $(FeS)_2Ni_3S_2$ no other compounds are present. The compound $(FeS)_2Ni_2S$, found by R. Bornemann is a ternary solid solution. Also the compounds $(FeS)_3(Ni_2S)_2$ and $(FeS)_4Ni_2S$ as well as the binary compound Ni_2S do not exist. In the field examined the primary crystallization starts with the following crystals: (1) binary solid solutions of either α- or γ-iron with Ni, (2) FeS, (3) ternary solid solutions of the ternary compound $(FeS)_2.Ni_3S_2$ and the compound Ni_3S_2 with excessive iron and nickel. The isothermal diagrams are described and diagrammatically presented. The results obtained have been checked by magnetic measurements of the transformation points. The constitution of nickel matte and the formation of triolite in meteoritic nickel iron are explained. GN(5a)

A Study of the Relation between Macro- and Microstructure in Some Non-Ferrous Alloys. MARIE L. V. GAYLER. (National Physical Laboratory.) *Institute of Metals, Advance Copy* No. 535 (1930), 12 pages, 6 references.

The effects of various casting conditions on the macro- and micro-structures were determined with a 5% lead-tin alloy, a 7% copper-aluminum alloy and an 11% silicon-aluminum alloy. As the casting temperature is raised the macrostructure becomes coarser, but the microstructure becomes finer. Variations in the ratio of the cross section of the mold to the cross section of the ingot affect both the micro- and macrostructures. Usually there is not much difference in the structures resulting in casting in a steel mold and in casting in a graphite mold. If the casting temperature is low, gases do not affect the structures, but with high casting temperatures gases affect the structures. Hydrogen causes the formation of a fine macrostructure. Furnace gases have little effect on modification. Modification of a silicon-aluminum alloy cannot be obtained by casting in a water cooled copper mold. JLG(5)a

Recent Investigations into the Recrystallization of Metals. (Neuere Untersuchungen über die Rekristallisation der Metalle.) Kaiser-Wilhelm-Institute für Metallsorschung, Berlin. *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, March 29, 1930, page 400.

This report largely deals with the experiments of G. Sachs on the cold-worked metals which later are annealed at increasing temperatures. The effects of annealing are rather complicated in all metals tested which cannot be briefly described. The laws of recrystallization can be observed by microscopic tests and also by X-ray photography. Especially clear pictures of the new structure of annealed, cold-worked metal samples are obtained by monochromatic X-rays. It can be stated that the lower the degree of cold-working the higher the recrystallization temperature and the coarser the new grain for the same annealing time. Mono-crystals recrystallize much later than materials of very fine grain treated in the same manner. The influence of intermediary annealings has also been investigated at different temperatures; for details the original paper must be referred to. Ha(5a)

Nature of Recrystallization Nuclei. (Das Wesen der Rekristallisationskeime.) A. E. VAN ARKEL. *Zeitschrift für Metallkunde*, Vol. 22, July 1930, pages 218–220.

Paper was presented before the Deutsche Gesellschaft für Metallkunde, Jan. 1930, Berlin. The result of the author's experiments is not in agreement with the generally accepted conception as to the nature of the crystal nuclei which are considered to represent smallest crystal splinters which remained undeformed during the deformation process. According to the author, slightest deformations will prevent crystals from growing. Arkel supports the statements of van Liempt emphasising the spontaneous formation of undeformed crystals or lattice sections free from internal stresses at parts of largest disturbance, i. e., at places where a surplus of deformation energy is available. EF(5a)

The Modern Methods of the Microscopic Metallography. (Les Methods modernes de la Métallographie microscopique.) R. CAZAUD. *Aciers Speciaux, metaux et alliages*, Vol. 5, May 1930, pages 195-200, 6 references.

The history of metallography is discussed, starting with Widmanstätten's work in 1808, Sorby in 1856, Osmond and Werth in 1883 and on up to date citing the most important work of metallographists from Germany, England, Sweden and United States. The technique of operation is described: preparation, polishing, etching, examination of structure and the use of high magnification microscope. GTM(5a)

The Limit of Solubility of Copper in Reversible Ferro-Nickel. (Limite de solubilité du cuivre dans les ferronickels réversibles.) P. CHEVENARD. *Comptes Rendus*, Vol. 189, Oct. 14, 1929, pages 576–578.

By means of a dilatometric method, it was found that the solubility of Cu in austenitic Fe-Ni alloys lies below the limits 25, 54, 21% and 5, 25, 70%, Cu, Ni, Fe, respectively. (5a)

The Kinetics of the Eutectoid Decomposition of the Gamma Bronzes. (Zur Kinetik des eutektoiden Zerfalles der gamma-Bronzen.) O. DAHL. *Zeitschrift für Metallkunde*, Vol. 22, Feb. 1930, pages 48–52, 4 references.

The present paper throws light on the age-hardening due to the eutectoid decomposition of the γ-phase in the Cu–Sn system. This phenomenon was followed by means of hardness and electrical resistance curves taken as a function of annealing times. The electric resistance curves show—instead of the expected rise in resistance—3 effects: a slight rise followed by a pronounced decrease and finally a permanent rise. The first rise corresponds to the abnormal increase of resistance due to the starting precipitation, whereas the fall is caused by the large precipitation of the α phase out of the γ solid solution. The last rise is ascribed to the eutectoid decomposition. The precipitation of the α-phase results in the age-hardening effect. The decomposition of the β-phase in the aluminum bronzes takes place in a similar manner. EF(5a)

On the Equilibrium Diagram of the Iron–Vanadium System. MASAKICHI ÔYA. *Science Reports Tohoku Imperial University*, Vol. 19, May 1930, pages 234–245.

Metallic vanadium of 98.4% purity was obtained by the thermite process, using a little less metallic aluminum than the theoretical and using Na_2CO_3 as the flux. The equilibrium diagram of the iron–vanadium system in the solid state has been investigated by making thermal, magnetic and microscopic analyses. The alloys of this system form a continuous series of solid solutions. With the addition of vanadium, the A_4 transformation of iron is lowered, while the A_3 is raised, so that the A_4 and A_3 curves meet at 2.5% content of vanadium to form a continuous phase boundary. The A_3 point is raised, gradually at first, up to a maximum at nearly 15% Va, then lowered rapidly, until it reaches room temperature in an alloy containing nearly 35% Va. (5a)

The Influence of Recrystallization upon the Technical Behavior of Lead. (Der Einfluss der Rekristallisation auf das technische Verhalten von Blei.) FR. BRENTHEL. *Zeitschrift für Metallkunde*, Vol. 22, Jan. 1930, pages 23–26.

The chemical analysis alone does not yield an indication of the usefulness of soft lead in service, and microexamination is emphasized. The influence of recrystallization upon chemical, mechanical and thermal behavior is mentioned. Lead produced by the Parkes and Pattinson-process are compared. Pattinson lead is homogeneous and recrystallizes with difficulty. Due to its structural stability, Pattinson lead displays superiority in chemical and fatigue resistance. The influence of "impurities," particularly Cu is considered. The paper, presented before the Deutsche Gesellschaft für Metallkunde, Düsseldorf, includes discussion. EF(5a)

Structure & X-Ray Analysis (5b)

X-Raying Die Castings. ANCEL ST. JOHN & H. R. ISENBURGER. *Iron Age*, Vol. 125, April 17, 1930, pages 1135–1137.

X-rays of die-cast test bars show that interior conditions depend upon construction of die. Three methods of X-ray examination of die castings: 1. Radiographic inspection with photographic film. 2. Radiographic inspection with photographic paper. 3. Visual inspection on a fluorescent screen. Defects of die castings arise principally from 2 causes: 1. Incorrect specification of die casting procedure. 2. Departure from specified procedure. Former leads to chronic defects, the latter to occasional. VSP(5b)

The Structure of Heusler Alloys. (Ueber den Bau der Heuslerschen Legierungen.) ELIS PERSSON. *Zeitschrift für Physik*, Vol. 57, No. 1/2, 1929, pages 115–133.

The ferro-magnetic Cu-Mn-Al alloys have been subjected to thorough metallographic investigations by means of X-rays in order to find definite corroboration that the carrier of magnetism was a certain kind of crystal, called β. This crystal has a body-centered cubic lattice structure in which the aluminum atoms occupy the points in such manner that a face-centered cubic super-structure is formed. The crystal is only magnetizable if the manganese-concentration exceeds a certain minimum value. A great number of alloys have been tested partly in quenched state, partly annealed 15 days at 210° C. The individual tests are illustrated by tables and diagrams. Ha(5b)

X-Ray Investigation of Alloys of Nickel–Cobalt and Iron–Cobalt Systems. ATOMI OSAWA. *Science Reports, Tohoku Imperial University*, Vol. 19, March 1930, pages 108–121.

An X-ray analysis of the alloys of nickel and cobalt, and of iron and cobalt has been made, the result of which confirms the correctness of the new diagram of these systems recently published by H. Masumoto. The relation between the lattice constant and the concentration in the nickel and cobalt alloys is represented by a linear equation as given by Vegard, while for the iron and cobalt alloys this relation does not hold good; and the lattice constant-concentration curve is represented by an equation of the second order. The axial ratio of a hexagonal cobalt is considerably decreased by the addition of nickel, but on the other hand, is increased by the addition of iron to cobalt. (5b)

The Distribution in Space of the Atoms in Alloys. (Ueber die Raumerfüllung der Atome in den Legierungen.) ARNE WESTGREN & ARNE ALMIN. *Zeitschrift für Physikalische Chemie*, Aug. 1929, pages 14–28.

The variation of the linear lattice dimension with the composition of the α-phases is investigated for the systems Ag–Al, Cu–Al, and Ni–Al; it is found that the lattice parameter has no additive connection with the parameters of the components. The volume per atom is calculated for both the several kinds of crystals of these systems as far as their structure has been determined, and for the phases of the systems Cu–Zn, Ag–Zn, Ag–Cd, Cu–Mg and Fe–W, from the dimensions of the lattice. It is shown that the formation of intermediary phases is usually connected with contraction which is particularly large for the Ni-Al phases. The reason for it is discussed. Many tables and curves illustrate the paper. Ha(5b)

X-Ray Investigation of Iron and Manganese Alloys. ATOMI ÔSAWA. *Science Reports, Tohoku Imperial University*, Vol. 19, May 1930, pages 247–264.

An X-ray analysis has been made of the iron–manganese system throughout its whole range. Hardness and density measurements were also made for the alloys containing from 0–50% of manganese. Four phases were found in the system by these measurements, that is α- and β-manganese, the body-centered phase (α-iron), and the hexagonal phase (Fe_3Mn). At a sufficiently high temperature, a solid solution of γ-iron and γ-manganese is found in the whole range of the system. The lattice constants of different modifications of pure manganese (α, β and γ) decrease with an increasing content of iron; while the lattice constants of the modifications (α and γ) in iron increase a little with the concentration of manganese. (5b)

Application of X-Rays to the Study of Plastic Deformation in Steel Wires and Molybdenum Ribbon. NORMAN PHILIP GOSS. (American Steel and Wire Co.) *Transactions, American Society for Steel Treating*, Vol. 17, Feb. 1930, pages 241–261.

Master's Thesis, Case School of Applied Science, May 1928. Following a brief description of the apparatus and technique used the general theory of X-ray analysis is discussed. The Laue method is stated to be superior to the Hull except in the case of severe plastic deformation. In the study of the effect of slight plastic deformation upon the structure of low carbon steel wire, it was found that preferred orientation, i. e., alignment of the (110) planes approximately at right angles to the wire axis, did not take place until grain fragmentation was complete (at from 10–15% draft). Two types of "radial asterism" were found, one due to the reflection of X-rays from curved crystalline surfaces, and the other to reflection from crystalline fragments of slightly differing orientation from fragment to fragment. Annealing a drastically cold-worked molybdenum ribbon was found to cause complete recrystallization, but directional properties were still in evidence even after weeks of heat treatment. WHK(5b)

Portable and Collapsible X-Ray Installations for Testing of Materials. (Ortsbewegliche und zerlegbare Roentgenanlagen für Werkstoffprüfungen.) *Zeitschrift Vereins deutscher Ingenieure*, Vol. 74, Jan 18, 1930, pages 89–90.

Description of a few installations in a railway car which permit one to see through steel of 40 mm. and iron of 60 mm. One plant can give continually 180 KV and 4 mA, another larger one 250 KV and 20 mA. Illustrations are given. Ha(5b)

The Crystal Structure of an Iron Phosphide. JAMES B. FRIAUF. (Carnegie Institute of Technology.) *Transactions, American Society for Steel Treating*, Vol. 17, April 1930, pages 499–508.

Paper presented before the Eleventh Annual Convention of the American Society for Steel Treating, September 1929. Crystals of Fe_2P were prepared which checked in appearance previously given descriptions and in analysis with the formula, Fe_2P. A mean value of density of 6.89 was determined which is not in agreement with previously reported values but is entirely in agreement with the X-ray data of this investigation. Laue photographs of Fe_2P show the crystals to be hexagonal. From Oscillation photographs the unit cell is determined as a = 5.87 A. U. and c = 3.45 A. U. which is in agreement with Hagg. WLC(5b)

X-Ray Testing of Aircraft Materials. A. ST. JOHN. *Preprint* 33, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 2 pages.

Argument for it. No description of methods. HWG(5b)

The Application of X-Rays to the Study of Metals. JAMES B. FRIAUF. *Review of Scientific Instruments*, Vol. 1, July 1930, pages 361–396.

The 3 methods for the X-ray study of metals are considered: (1) the use of X-rays for the radiographic examination of metals, (2) the use of X-rays for the determination of chemical composition by the methods of X-ray spectroscopy, and (3) the use of X-rays for the study of the crystalline structure of metals. This latter method includes the determination of the crystal structures of the different constituents of alloys and the identification of the crystalline phases present in alloy systems, and the determination of orientation and grain size and the study of other properties of crystals, or crystal aggregates of knowns tructure. (5b)

Determination of the Orientation of Single Crystal Specimens of Metals of the Hexagonal System. THOMAS A. WILSON. *Physical Review*, Vol. 33, June 1929, page 1087.

The X-ray method described for cubic single crystals has been extended to hexagonal crystals with an application to Zn. (5b)

The Production of Two Forms of Pure Iron, Stable at Ordinary Temperatures, by Annealing. (Sur la production par les recuits des deux états du fer pur, stables a la témperature ordinaire.) R. FORRER & J. SCHNEIDER. *Comptes Rendus*, Vol. 190, June 16, 1930, pages 1391–1393.

The variation of the magnetization of iron in a field which compensates for the tendency of the material to demagnetize itself has been studied as a function of the temperature of annealing. Two maxima are found. This indicates the existence of 2 forms of iron, one of which forms on annealing at 200° to 400° and the other on annealing at 450° to 900°. This behavior is indicated on the basis of an hypothesis advanced by one of the authors. The first form, according to this hypothesis, is a symmetrical triplet, the second an unsymmetrical triplet. Both are stable at ordinary temperatures. Certain impurities in the samples seem to favor the formation of the latter. (5b)

Lattice Distortion as a Factor in the Hardening of Metals. WM. L. FINK & KENT E. VAN HORN. (Aluminum Company of America.) *Institute of Metals, Advance Copy* No. 534 (1930), 7 pages, 5 references.

Strips of heat-treated "17S" (Duralumin) alloy and annealed brass were stressed by bending in a special fixture and while stressed X-ray diffraction patterns and Rockwell hardness measurements were obtained. The stress in the portion of the sample studied was calculated by means of the bending formula. All stresses were under the elastic limit. The apparent Rockwell hardness was lowered by stressing, which is explained as resulting from the combined action of the stresses in the material and the pressure exerted by the ball. The X-ray diffraction patterns indicated a distortion of the lattice by the stresses below the elastic limit. JLG(5b)

X-Ray Crystal Analysis in Engineering. V. E. PULLIN. (Research Department, Woolwich.) *Engineer*, Vol. 150, July 4, 1930, pages 2–4.

Explains in general terms what crystal analysis depends upon and how it is done. Shows from typical spectra how their interpretation is important to general engineering practice. Physicist and engineer must coöperate in order that both will obtain maximum benefit in the practical application of the subject. Some of the metals considered include iron, manganese steel, "Staybrite" steel, and electro-deposited nickel. Deals briefly with application of X-ray to chemical analysis. LFM(5b)

An X-Ray Investigation of the Copper-Antimony System of Alloys. E. VYRON HOWELLS & W. MORRIS-JONES. *Philosophical Magazine*, Vol. 9, May 1930, pages 993–1014.

The results are summarized in the table.

% Cu by Weight	Density	Parameters in A. U.	Lattice Type
100	8.93	3.610	F. C. C.
96	8.75	3.644	F. C. C.
80	8.26	3.670 & 2.728, 4.288	F. C. C. & H. C. P.
70	8.34	2,728, 4.288	H. C. P.
65	8.64	2.752, 4.326	H. C. P.
61	8.66	2.766, 4.348	H C. P.
55	8.30	2.766, 4.348 & 4.029, 6.140	H. C. P. & S. T.
51	8.42	4.029, 6.140	S. T.
30	7.45	4.020, 6.126 & 6.235	S. T. & F. C. R.
20	7.02	4.024, 6.133 & 6.240	S. T. & F. C. R.
0	6.62	6.235 Angle = 87°24′	F. C. R.

F. C. C. face centered cubic; H. C. P. hexagonal close packed; S. T. simple tetragonal; F. C. R. face centered rhombic. (5b)

Silicon Transformer Steel Residue. W. A. WOOD. *Nature*, June 28, 1930, Vol. 125, page 974.

In "Applied X-rays," G. L. Clark shows the connection between the magnetic hysteresis loss and the grain size of a 4% Si steel and quotes a formula connecting the number of spots on a Laue photograph with the magnetic hysteresis loss of the steel: the fewer the spots, the less the loss. The author takes exception to that rule and presents experimental evidences of the contrary. (5b)

PHYSICAL, MECHANICAL & MAGNETIC TESTING (6)

Effect of Mechanical Stress on Magnetic Testing of Materials (Der Einfluss mechanischer Spannungen auf magnetische Werkstoffprüfungen.) K. KETTNER. *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Jan. 25, 1930, pages 122–123.

A few results on the interrelation between mechanical stresses and induction at different magnetizing forces in longitudinal and transverse directions. Ha(6)

Continuous Tests on Riveted and Welded Bridges. (Dauerversuche an genieteten und geschweissten Brücken.) R. BERNHARD. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Nov. 23, 1929, pages 1675–1680.

These tests were made to determine the behavior of a bridge under a continuous test. One riveted and one welded bridge were exposed to eccentrically arranged vibrating loads. The method of testing and the instruments used are described in detail. A definite conclusion could not, however, be arrived at due to the still imperfect testing method. Ha(6)

The Manufacture and Uses of Stellite. C. W. DRURY. (Deloro Research Laboratories.) *Canadian Mining & Metallurgical Bulletin* No. 219, July, 1930, pages 930–947.

The methods of manufacture, tests (Rockwell, break, microscopic, lathe, fluidity and abrasive), physical and chemical properties and uses of stellite are briefly described. AHE(6)

Demagnetisation Factor and Ideal Induction Curve of Various Sample Shapes. (Entmagnetisierungsfaktor und ideale Induktionskurve verschiedener Probeformen.) H. LANGE. *Mitteilungen Kaiser Wilhelm Institut für Eisenforschung*, Vol. 11 (1929), *Report* 141; pages 387–396; *Stahl und Eisen*, Vol. 50, Feb. 27, 1930, pages 264–265.

Magnetic investigations on the influence of the shape of the sample tested on various magnetic values prove that the shape of an approximate ellipsoid or, briefly called, a cone-shaped bar is most suitable for correct measurements in practical application. GN(6)

Strength in Shear of Thin Curved Sheets of Alclad. GEORGE MICHAEL SMITH. *National Advisory Committee for Aeronautics, Technical Note* No. 343, June 1930, 27 pages.

Article describes tests made on 17ST duralumin coated with aluminum. (6)

New Hardness Testers (Neuere Härteprüfer). *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Mar. 1, 1930, page 272.

Description of a new automatic Brinell-tester which is easily transported and weighs only 30 lbs. Ha(6)

The Mechanical Properties of Cast Iron. (Die mechanischen Eigenschaften des Gusseisens.) A. THUM & H. UDE. *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, March 1, 1930, pages 257–264.

The difference in mechanical properties of cast iron and steel are discussed very exhaustively. They are due to the structure of the cast iron. This investigation deals with tensile strength, elasticity, toughness, fatigue strength, fatigue impact strength and sensitivity against notching, all of which properties are illustrated by curves. The author considers cast iron to behave like notched steel. It is recommended to extend the investigations into machinability, hardness, wear, and temperature resistance-properties which are of great importance for given uses. 11 references. Ha(6)

Development of a Method of Measuring Concentrated Stresses. J. F. QUEREAU. (Leeds & Northrup.) *Mechanical Engineering*, Vol. 52, June 1930, pages 611–613.

The lateral deformation of a material may be taken as a measure of the stress in the material. The use of lateral deformation as a measure of stress may be utilized in the measurement of localized stress, provided a sensitive extensometer is available. A new extensometer was developed. Results with this extensometer are consistent and compare favorably with those obtained by other experimental methods. GN(6)

Manufacture and Properties of Light Welded Tubing. *Iron Age*, Vol. 125, April 17, 1930, page 1146.

Thin walled tubing, made by electrical resistance welding by Steel & Tubes Inc., Cleveland, has been investigated at Bureau of Standards and results published by Messrs. Whittemore, Adelson and Seaquist. See *Metals & Alloys*, July 1930, page 629. VSP(6)

Fatigue Fractures of Steel Castings and Forgings. (Ermüdungsbruche an Stahlguss-und Schmiedestücken.) R. MAILANDER. *Stahl und Eisen*, Vol. 50, July 3, 1930, pages 970–971.

A paper by R. A. MacGregor before the Annual Meeting of the North-East Coast Institution of Engineers and Shipbuilders, January 24, 1930 at New Castle-upon-Tyne, is reviewed. According to MacGregor the process of fatigue is due only to local, in the beginning microscopic, fine cracks. Any kind of property changes cannot be found. The relation between the area of fatigue fracture and the rest of the area permits one to draw conclusions as to the factor of safety in constructions. The causes of fatigue fractures are given, among which he mentions unexpected oscillations. Grain size, relation between limit of proportionality and tensile strength, type and size of inclusions should be especially considered in judging the properties of materials for alternating stresses. GN(6)

Indirect Magnetometric Methods for Steel Testing at Ordinary Temperatures. (Indirekta magnetiska metoder für stalundersökning vid vanlig temperatur.) HARALD SJOVALL. *Jernkontorets Annaler*, Vol. 114, June 15, 1930, pages 304–319.

General discussion and review of magnetic methods for steel testing, devoted principally to description of apparatus. A two page bibliography is appended which covers 36 contributions to the field for each year from 1917 on. HCD(6)

Thick-Walled Tubes and Cylinders Under High Pressure and Temperature. R. W. BAILEY. *Engineering*, Vol. 129, June 13, 1930, pages 772–773; June 20, 1930, pages 785–786; June 27, 1930, pages 818–819.

Contribution based on experimental work on the creep of metals under both simple tension and compound stresses. Reference is made to author's previous work on thin-walled tubes. Little work has been done on the creep of metals under pure shear. Such tests should form basis of a rational treatment of the creep of tubes or cylinders under internal pressure with or without heat transmission through the wall. Many mathematical equations and graphs are given. LFM(6)

The 136° Pyramid Hardness Test on Cast Iron. A. L. NORBURY. *Bulletin, British Cast Iron Research Association*, July 1930, pages 271–274.

Tests show that Brinell hardness number increases and decreases with increase in load. Similar tests with 136° pyramid show hardness numbers are independent of the load up to 10,000 kg. Illustrations give the relations between size of impression and variations between repeat hardness tests. Relation between Brinell numbers and 136° pyramid numbers for load of 3,000 kg. in each case is shown in a graph. (6)

Brinell hardness, elastic limit, and tensile strength of age-hardening aluminum alloys. (Brinell Härte, Elastizitätsgrenze und Zugfestigkeit vergüteter Aluminiumlegierungen.) H. BOHNER. *Zeitschrift für Metallkunde*, Vol. 21, Nov. 1929, pages 387–389.

The influence of various loads and times under loads upon the Brinell Hardness is investigated. Measurements are made with 4 alloys of different composition. The samples were all quenched from 540° C. Some are artificially aged at 120° C. and others at 140° C. The loads applied, using a 5 mm. ball, were 62.5, 125, 250 and 750 kg. and with a 10 mm. ball: 250, 500, 1000 kg. The range of time was varied from 5 sec. to 5 min. to throw light upon the influence of time on the Brinell Number. The results may be summarized as follows: The Brinell hardness number increases in all samples investigated with increase in load. Regardless of the ball diameter the hardness number is the same providing the respective loads are always a constant quantity times the square of the ball diameter. The increase in Brinell Number with load is the greater the higher the Brinell Number at the lower load. This relationship is illustrated by a table and a diagram which gives values for soft Al, Cu and steel. Regarding the influence of time it was found that there is only a very slight difference. A formula, substantiated by a great amount of data, is given: elastic limit + tensile strength × 2 = Brinell Number if the load is five times the ball. This holds for Al alloys containing 4 to 7.5% Cu, after age-hardening. EF(6)

"Pendulum" Hardness Tests of Commercially Pure Metals. D. A. N. SANDIFER. (The University, Birmingham.) *Institute of Metals, Advance Copy* No. 529 (1930), 29 pages.

Herbert pendulum tests were made on 23 metals of as high a purity as could be readily obtained. All samples were in the cast or annealed condition. Time and scale hardness and time and scale "work-hardening capacities" were obtained. Some of the time hardness values (3 mm. ball—0.21 mm. pendulum length) were: lead 2.33, magnesium 5.22, aluminum 9.37, silver 9.48, gold 9.38, zinc 11.77, copper 12.29, iron 18.14, tungsten 45.71 and manganese 60.25. Determinations of "Time work-hardening capacity" showed that some metals are hardened very little, others very much, while others lie between these 2 extremes. Lead, bismuth, tin, cadmium, tantalum, zinc and tungsten show very little work-hardening, while molybdenum, chromium, cobalt, rhodium and iridium harden very rapidly. Manganese (97 to 98% pure—carbon free) is unique in that it shows a negative "work-hardening capacity." The values of time hardness plotted against the reported values of Young's modulus yielded a straight line. These same hardnesses plotted against the relative atomic volume yield an hyperbola. In hardness values obtained on a series of copper strips having various reductions by cold rolling the time hardness (0.10 mm.) increased from 14.41 at no reduction to 27.74 at 89.4% reduction, while the "time work-hardening capacity" decreased from 19.7 to 1.67. Similar tests were made on cold rolled aluminum and magnesium, but the detailed values are not given. When other elements were added to gold or silver both the time hardness and "the work-hardening capacity" were increased, but with increasing amounts of alloying elements the latter value was lowered. JLG(6)

A 3,000,000-lb. Testing Machine. W. M. WILSON. *Engineering & Contracting*, Vol. 69, Aug. 1930, pages 292–293.

Description of the 3,000,000 lb.-tension and compression testing machine built by the Southwark Foundry & Machine Co. for the Materials Testing Laboratory of the University of Illinois. GN(6)

Fatigue Fracture and Fatigue Strength. (Dauerbruch und Dauerfestigkeit.) R. KUEHNEL. *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Feb. 8, 1930, pages 181–184.

Supplementing a previous article on this subject in Vol. 71, 1927, page 557. See *Metals & Alloys*, Vol. 1, May 1930, page 524. Ha(6)

Instrument for Measuring Drilling Resistance. (Gerät zum Messen des Bohrwiderstandes.) O. SCHWENNINGER. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Dec. 21, 1929, pages 1826–1827.

The article describes an apparatus made by Alfred F. Amsler & Co., Schauffhausen, which measures and records by means of a spring-indicator the torque and pressure exerted during drilling of holes through materials. Ha(6)

New German Tensile Testing Machines. (Neue deutsche Zerreissmaschinen.) M. MOSER. *Stahl und Eisen*, Vol. 50, July 31, 1930, pages 1086–1088.

The article describes and illustrates some new German tensile testing machines the details of which fulfill the requirements of the Material Testing Committee of the Verein deustcher Eisenhüttenleute. The description covers a 60-ton universal hydraulic testing machine built by Losenhausen A. G., at Düsseldorf, a 50-ton mechanical tensile testing machine which is built as a special machine for fine measurement tests by Mohr & Federhaff, and finally a 50-ton tensile testing machine for hot tensile tests built by Man, Nürnberg. This machine is also mechanically driven. GN(6)

Mechanical Testing of Aircraft Materials. J. B. JOHNSON. *Preprint* 33, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 8 pages.

Some details of methods used for determining tensile, bend, hardness, impact, shear and torsion properties of aircraft purchased to specifications. HWG(6)

The Magnetization Diagram of Nickel-mono-crystals. (Ueber des Magnetisierungs-diagram von Nickeleinkristallen.) G. T. SIZOO. *Zeitschrift für Physik*, Vol. 57, no. 1/2 (1929), pages 106–114.

A simple and quick method has been developed to obtain long, wire-shaped nickel crystals. The magnetization curves of nickel crystals are the same as those of iron crystals of a lower part where magnetization is connected with hysteresis and of an upper part, where the magnetization is perfectly or almost perfectly reversible. In the lower part of the curve the occurrence of kinks could be determined with great probability of which the last one leads to the reversible part of the curve. The strength of remanence depends on the direction of the crystal and reaches a maximum probably in the direction of the tetragonal axis. The ideal magnetization curve of a crystal has been measured and the starting susceptibility was found to be infinitely large. Ha(6)

Effect of Section Size on Physical Properties of Cast Iron. A. L. BOEGEHOLD. Work for Sub-Committee XIV of A.S.T.M. Committee A-3 on Cast Iron. Appendix to Report of Committee A-3, *Preprint* 11, June 1930 Meeting, *American Society for Testing Materials*, 6 pages.

Six flat test bars were poured from the same gate, all 1¼" wide, with thickness varying from ⅛–1¼". Ends were cored to reduce the effect of change of section. The dense structure produced by skin cooling was removed from 2 sides of each bar, leaving 2 un-machined faces, to simulate a casting machined to retain the cast surface on 2 sides. Two electric furnace irons were used, one (No. 1) with 3.68% total carbon, 2.30% silicon; the other (No. 2) with 3.40% total carbon, 2.20% Si, 1% Ni, ¼% Cr. No. 1 dropped from 29,000 lbs./in.² tensile at ⅛" to 24,000 at ½" and 20,000 for ¾–1¼". Brinell was 255 in ⅛", 165–170 in all larger sizes. No. 2 dropped from 33,500 at ¼" to about 27,000 at 1¼". Brinell dropped smoothly from 210 at ¼" to 185 at 1¼". No sure correlation is shown between Brinell and tensile for irons in general. Special correlation has to be established for each iron. Micrographs are shown. HWG(6)

Fatigue Tests of Fillet Welds. R. E. PETERSON & C. H. JENNINGS. *Preprint* No 40, June 1930 Meeting, *American Society for Testing Materials*, 10 pages.

When a 1" diameter rod is welded to an abutting 2" diameter rod by a fillet weld encircling the junction, without any welding of the abutting faces, and the welded assembly subjected to cantilever rotary beam fatigue tests, it was found that: leaving space between the abutting faces weakens the weld considerably, they should be in close contact: if the fillet (width of ring of weld metal) is less than 0.3" failure occurs in the weld starting from the inside and the strength is low: with sufficient weld metal, failure occurs at the base of the weld. The amount of weld metal makes little difference: since failure starts at the base of the weld (through the parent metal in a fused area), machining a radius at the junction of weld and 1" rod has no effect. Properly welded fillet welds have an endurance limit of about 18,000 lbs./in.². The welded rods were hot rolled steel 0.12% C, 0.50% Mn and the welding electrodes were 0.15% C, 0.49% Mn, uncoated Electric welding at 150 amperes was used. HWG(6)

Photoelastic Studies of Aircraft Parts. T. H. FROST. *Preprint* 33, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 5 pages.

Celluloid models of aircraft parts examined in polarized light show distribution of stresses. The method is useful in design. HWG(6)

Fatigue Studies of Telephone Cable Sheath Alloys. J. R. TOWNSEND & C. H. GREENALL. *Preprint* 41, June 1930 Meeting, *American Society for Testing Materials*, 9 pages.

In study of fatigue properties of cable sheath alloys, a preliminary survey is made using a constant deflection method on a flat cantilever specimen at a single deflection, under which pure lead fails in 0.3 to 1.3 million cycles and a 1% antimony alloy in 1.8 to 2.6. Alloys of refined lead with 0.04% calcium ran for 13 million as a minimum up to 169 million unbroken. Very small amounts of Sn or Sb injure the calcium-lead alloy on this test and it is stated that it will detect the effect of 0.001% As, which is not shown by tensile test. Actual endurance tests are made on a cantilever type rotating beam machine. Refined lead, unalloyed, shows a 50 million cycle endurance limit at 215 lbs./in.² The same with 1% Sb shows 450 and with 0.04% Ca 840 lbs./in.² S-N curves are given. Static flow tests (mis-named static "fatigue" tests in the paper) show an elongation in 3000 hrs. at 920 lbs./in.² of 0.02" in 2" for the calcium alloy and 0.10" for the 1% Sb alloy. For metallographic and other data on these alloys, see *Metals & Alloys*, March 1930, pages 405, 410. HWG(6)

Recent Results of Wear Research. (Neuere Ergebnisse der Abnutzungsforschung.) M. FINK. *Zeitschrift Vereins deutscher Ingenieure*, Vol. 74, Jan. 18, 1930, pages 85–87; *Metallurgist*, May 1930, pages 66–68.

The phenomenon of wear comprises 2 principal phenomena: 1. The mechanical separation of small particles. 2. Cold-deforming and cold-hardening of the material; the use of intermediaries was not considered, as emery or carborundum, as cause for wear, only sliding or rolling friction of similar or other standard materials. The whole process of wear and its measurement is investigated and certain causes are found; means for reducing the effect are discussed and testing machines illustrated. See *Metals & Alloys*, April 1930, page 473. Ha(6)

Relationships between Rockwell and Brinell Numbers. S. N. Petrenko. *Bureau of Standards Journal of Research*, Vol. 5, July 1930, pages 19–50.

Comparative Rockwell and Brinell tests were made on a great variety of ferrous and non-ferrous metals. Relationships between Brinell and Rockwell numbers, based on certain simplifying assumptions, are:

$$\text{Brinell number} = \frac{\text{constant}}{130 - \text{Rockwell ball number}}$$

and

$$\text{Brinell number} = \frac{\text{constant}}{(100 - \text{Rockwell cone number})^2}$$

These equations were used as guides in finding empirical formulas which fitted most closely the values determined experimentally. Of all the experimental values obtained in this investigation very few differed by more than 10% from values obtained from these empirical equations. Empirical equations were also found giving the tensile strengths of steels in terms of their Rockwell numbers. Experimental values checked these equations within an error of plus or minus 15%. (6)

Hardness by Mutual Indentation. I. H. Cowdrey. *Preprint* 52, June 1930 Meeting, *American Society for Testing Materials*, 12 pages; *Engineering*, Vol. 130, Aug. 29, 1930, page 282.

Crossed prisms or cylinders have been used for hardness testing. In this paper mutual flattening of two cylinders of the same material, with their axes parallel, is discussed. Specimens may be 5, 10 or 15 mm. diameter cylinders of 10 or 15 mm. length, 10 mm. is better for hard steels. They are held in hardened steel fixtures which support them over half of their circumference, and hold them in alignment. A guide block is provided and the whole placed under the ram of a Brinell machine. The width of the flat area produced is measured by a Brinell microscope. When Brinell hardness is less than 150, any load that will produce an easily measurable flattening will serve. At higher hardness 3000 kg. pressure is required. The cylinder hardness number $= \frac{P}{WL}$ where P is load in kilograms, W width of indentation in millimeters and L original length of test cylinder in millimeters. The cylinder hardness number is 1.52 times the Brinell number. With proper loads, as defined above, so that sufficient local flow, but without general flow, is obtained, the maximum deviation from the 1.52 ratio to Brinell number was 6% and the average deviation 1½%. Mutual indentation methods are applicable to hardness determinations at high temperatures where softening of the ball might be met, to small wires and to bearing metals. They are not applicable to surface-hardened materials. The use of V blocks instead of semi-cylindrical blocks is to be studied. LM+HWG(6)

Specimens for Torsion Tests of Metals. R. L. Templin & R. L. Moore. *Preprint* 50, June 1930 Meeting, *American Society for Testing Materials*, 10 pages; *Engineering*, Vol. 130, Aug. 29, 1930, page 281.

Discussion of tests of aluminum alloys in torsion, using Amsler machine and Martens mirror strain-gage. Various ratios of outside diameter to wall thickness of hollow specimens were used. The modulus of elasticity in shear may be obtained either from solid or hollow specimens. For shearing strength hollow specimens with outside diameter 12 to 14 times the wall thickness and length of reduced (thin walled) section about half the outside diameter, are satisfactory. For elastic limit and yield point, the outside diameter should be 10 times the wall thickness. Increased demand for data on shearing properties emphasizes the need for a definite form of specimen and method of test. Torsion testing offers a profitable field for further study. LM+HWG(6)

The Effect of Understressing on Cast Iron and Open-Hearth Iron. J. B. Kommers. *Preprint* 39, June 1930 Meeting, *American Society for Testing Materials*, 14 pages; *Engineering*, Vol. 130, Aug. 29, 1930, page 282.

The phenomenon of strengthening by understressing, through which a material subjected to repeated stress at or a little below the endurance limit of the virgin material, acquires a new and higher endurance limit, was studied. Using a cast iron of 20,000 lbs./in.² tensile, 174 Brinell with 3.03% graphitic C, 0.43% combined C, 2.19% Si, 0.61% Mn, 0.13% S and 0.27% P, whose endurance limit was 9300 lbs./in.², it was found that 20 million cycles at 9300 lbs./in.² produced a new endurance limit of 12,200 or 31% improvement. The improvement for the same number of cycles at lower stresses was as follows: 9000 lbs./in.² 25%; 8500, 23%; 8000 down to 6500, all 16%. At 9000 lbs./in.² 15 to 40 million cycles all gave the same improvement. The improvement for the same number of cycles at lower stresses was as follows: 9000 lbs./in.² 25%; 8500, 23%; 8000 down to 6500, all 16% at 9000 lbs./in.² 15 to 40 million cycles all gave the same improvement, 25%; 2½ million gave 13%; 5 million, 18%; and 10 million, 20%. Surprising results were obtained in a study of the endurance of this gray iron with an endurance bar reduced from ½″ diameter to ⅓″ diameter over a ¼″ span, without any fillet, i. e., with a sharp-edged groove. The endurance limit was 9300 lbs./in.², just the same as with the standard, smoothly-radiused bar. The localized stress due to the notch is less than that due to the carbon flakes. With Armco iron, of normal composition, hot-rolled, with 47% elongation, 75% reduction of area, 83 Brinell, having a virgin endurance limit of 26,200 lbs./in.², which is above the yield point of 22,700 and 60% of the tensile strength (44,000), understressing for 20 million cycles at the endurance limit, gave it a new endurance limit of 28,700 lbs./in.² or only 10% improvement. In the notched endurance test, the endurance limit fell to 18,500 lbs./in.², a reduction of 30%. By understressing the notched bar at its own endurance limit, its limit was raised 9%, to 20,100 lbs./in.² Cold-drawn Armco iron of a special grade known as S. S. magnetic, with 0.04% C, 0.03% Si and 0.02% Mn, having 73,000 lbs./in.² tensile and 69,000 yield point, 12% elongation, 63% reduction of area, 142 Brinell, gave an endurance limit of 33,000 lbs./in.² Cold drawing raised the endurance limit, but much less than the tensile and yield. The conclusions are that Armco is strengthened very much during the standard fatigue test, as is shown by the endurance limit being above the yield. It is homogeneous and has no internal notches analogous to the graphite flakes of gray iron. Its virgin endurance limit is relatively high and the understressed endurance limit does not go far above it. In gray iron the internal notches so raise the local applied stress that only when the calculated stress is low can the strengthening process become effective. When it can become effective, however, it increases the virgin endurance limit more than in a more homogeneous material. All the observations are consistent with the idea that in fatigue there is a race between a strengthening and a destructive phenomenon. They are also in line with the idea that strengthening by under stressing is closely allied to a cold-working process operating on a very minute scale. LM+HWG(6)

A Magnetic Strain Gage. J. P. Shamberger. *Preprint* 107, June 1930 Meeting, *American Society for Testing Materials*, 7 pages.

In a magnetic strain gage, movement of the gage arms causes movement of the armature in the air gap between 2 reactors, which produce a voltage change in the reactors. The voltage change is recorded by an oscillograph for dynamic testing, or by rectifier and D. C. meter for static testing. For dynamic work there must be supplied a high-frequency motor generator set, oscillograph, potentiometer, etc. It is rugged and applicable to study of railroad track stresses, or to gaging of dimensions of machined products. Design, calibration and applications are discussed. HWG(6)

The Influence of Mechanical Stresses on Magnetic Test Methods for Materials. (Der Einfluss mechanischer Spannungen auf magnetische Werkstoffprüfungen.) *Zeitschrift Vereins deutscher Ingenieure*, Vol. 74, Jan. 25, 1920, pages 122–123.

Magnetic measuring methods for determining the quality of materials, especially of joints, finds an increasing favor because this method permits a test on the finished piece without destroying or harmfully influencing it. It must, however, be used with great care as at present no sure indication exists in how far magnetic properties are influenced by, and are dependent on, internal stresses. Ha(6)

The Unbalanced Alternating Current Bridge for Magnetic Analysis. W. B. Kouwenhoven & A. C. Seletzky. *Preprint* 37, June 1930 Meeting, *American Society for Testing Materials*, 14 pages.

Comparison method in which the sizes of the standard and the unknown specimen may vary considerably (the unknown having from a quarter to twice the cross section of the standard). The bridge circuits are shown, and the theory discussed. In tests of strip it is alleged that this method of testing tends to group together specimens from different lots (heats) of steel when the differences in chemical composition are almost within analytical error. In knife blades, the method shows fair correlation with Brinell hardness and is claimed to differentiate among specimens of the same Brinell but quenched from different temperatures. HWG(6)

Fatigue Failure of Steel. W. R. Ormandy. *Iron & Coal Trade Review*, Vol. 120, Mar. 28, 1930, page 534; *Chemical Age*, Vol. 22, Mar. 22, 1930, page 269.

Very brief abstracts of a paper entitled: "Chemical Action in Relation to Fatigue Failure of Steels" and read before the Birmingham and Midland Section of the Society of Chemical Industry, at Birmingham, Mar. 20, 1930. Discusses the effects of chemical action due to distilled water, sea water ammonia and other reagents. RHP(6)

A New Testing Machine for Deep Drawing Sheet Materials. (Ein neues Prüfgerat für Tiefziehbleche.) G. Sachs. *Metallwirtschaft*, Vol. 9, March 7, 1930, pages 213–218.

A new type of testing machine has been developed in which a wedge shaped test piece is drawn through a die. The die is held in the upper jaw of a regular tensile testing machine and the lower end of the test piece in the lower jaw. Both the force required to pull the test piece through the die and the elongation are measured. Tables giving figures for Al, Cu, brass and soft steel sheets are given. CEM(6)

Elastic Behavior of Spring Materials. M. F. Sayre. *Preprint*, June 1930 Meeting, *American Society for Testing Materials*, 15 pages.

Hysteresis loops in static loading, taken with sensitive extensometers, and dead load tests on wires approximately 50 feet long lead to the conclusion that the modulus of elasticity is not constant and the stress-strain diagram for the materials tested is really curved. Heat-treated carbon steel wire (0.67% C) and 17 S "aluminum" (duralumin) wire (complete composition, heat-treatment, tensile strength, etc., not stated) were tested in dead weight loading. The modulus decreased linearly with increase in load from around 30 million at low loads to around 29 million at 160,000 lbs./in.² on the steel and from around 10.3 million at low loads to 10.0 million at 25,000 lbs./in.² on the 17 S alloy. Similar curved stress-strain diagrams were found for 3½ nickel steel (carbon and mechanical properties not given) and for spring tempered phosphor bronze (composition and mechanical properties not given). The results are expressed by formulae of which the following are examples:

Specimen 530 3½ nickel steel at 78° F. Modulus 29,140,000 — 4.3 S
Specimen 476 3½ nickel steel at 73° F. Modulus 28,930,000 — 10.9 S

where S is unit stress in tension in lbs./in.² No explanation is given for the variation in the factor by which S is to be multiplied. It is claimed that the theories of atomic attraction and repulsion call for a curvature of the stress-strain diagram. HWG(6)

A Note on Fatigue Tests of Nitrided Steel. N. L. Mochel. *Preprint* 42, June 1930 Meeting, *American Society for Testing Materials*, 5 pages; *Engineering*, Vol. 130, Aug. 29, 1930, page 282.

Nitriding steel of 0.35% C, 0.59% Mn, 0.22% Si, 0.20% Ni, 1.67% Cr, 0.91% Al, 0.20% Mo, 1750° F., oil, 1100° F. 1 hr., furnace cooled, was rough machined to +0.02″, then annealed at 1000° F. 3 hrs., furnace cooled, and finish machined to Standard tensile, Izod and endurance specimens. Some specimens were tested without nitriding, others after nitriding at 950° F. for 90 hrs. The tensile strength, about 160,000 lbs./in.², was unchanged. Elongation dropped from 16 to 6%. Reduction of area from 49 to 8%. Izod from 20 to 30 ft. lbs. down to 8 to 13. The endurance limit before nitriding was 76,000 lbs./in.² After nitriding it was 84,000 lbs./in.² and 2 nitrided specimens at 84,000 were run to 225 million cycles unbroken. A few specimens nitrided at 1000° F. for 48 hrs., were tested in the endurance runs and these points were close to the curve. The unnitrided steel was 340 Brinell. The nitrided specimens had 974 to 1064 Vickers Pyramid No. The thickness of nitrided case is not stated. LM+HWG(6)

The Effect of Cold-Working on Young's Modulus of Elasticity. Tadashi Kawai. *Science Reports, Tohoku Imperial University*, Vol. 19, May 1930, pages 209–234.

The effect of cold-working on Young's modulus of elasticity was determined for Armco iron, mild steel, nickel steel, copper, aluminum and nickel. In iron and steel the modulus always decreases by cold-working and in the other metals it decreases for a small degree of working, but increases for a large degree of working. The author has attributed the above changes of the modulus to a combined effect of 2 mutually opposing factors: (1) internal stress which arises in the metal due to cold-working and makes the modulus decrease, as has been theoretically proved by Prof. Honda, and (2) rotation of crystal grains of the metal due to cold-working which according to the author's view will increase the modulus. (6)

On the Stress-Strain Relation in the Impact Test. Tomiya Sutoki. *Science Reports Tohoku Imperial University*, Vol. 19, March 1930, pages 1–15.

Stress-strain diagrams at high temperatures have been obtained with the Charpy machine, by the same method as that of Körber and Storp with some improvements. The materials tested were carbon steels containing 0.3 and 0.5% of carbon, the test-piece being of the Izod type. The highest temperatures at which the test-pieces of these steels were perfectly broken, was about 600° and 650°, respectively. The following results were obtained: (1) A test-piece of a brittle material breaks abruptly at a maximum stress; but in the case of a tough material, the break takes place in several steps. (2) The bending of the test-piece increases almost linearly with the rise of temperature, but from 250–300° it begins to decrease, falling almost to the value at an ordinary temperature at about 550°. Above 550° it rapidly increases. (3) K. Honda's view regarding the thermal brittleness has been confirmed by the present investigation. (6)

ELECTRO-CHEMISTRY (7)

Electrochemical Interactions of Tungsten, Thorium, Caesium and Oxygen. Irving Langmuir. (General Electric Co.) *Industrial & Engineering Chemistry*, Vol. 22, April 1930, pages 390–393, 10 references.

The Chandler Lecture for 1929 at Columbia University. It presents summarily the results of studies of gas reactions and of the electrical properties of adsorbed films on filaments and their bearing on the electrochemistry of electrodes in solution. MEH(7)

Electroplating (7a)

Electrolytic Deposits of Cadmium. (Elektrolytische Kadmiumniederschläge.) W. H. CREUTZFELDS. *Stahl und Eisen*, Vol. 50, July 3, 1930, page 971.

The doctor thesis of B. Planner at the Technische Hochschule at Darmstadt (Robert Noske, Leipzig-Borna, (1929)) is reviewed. Cadmium was deposited on sheet iron in solutions of potassium cyanide, fluosilicic acid, chloric acid and phenol sulphuric acid. The deposits were judged according to (1) appearance (2) efficiency of current for different densities of current and different temperatures (3) density of the deposit. GN(7a)

Direct Chromium Plating. *Metal Industry* (London), Vol. 36, Feb. 7, 1930, pages 175–177.

Relates to method for direct deposition of Cr in contra-distinction to method of Cr deposition currently practiced. It is known as the Nast process. Advantages claimed for this process are: (1) Cr in direct contact with base metal, amalgamates with it and will neither peel nor chip; (2) direct process is cheaper, because it saves the process of Ni plating first. Northern Chromium Plating Co., Newcastle, are exploiting the new process. Briefly the process is as follows: (1) Article is dismantled and de-nickelled; (2) Ground and buffed until base metal has a perfect polish; (3) It is wired for hanging in Cr bath; (4) Degreased in special bath; (5) Article comes out of Cr bath with bright surface, which requires very little polishing. VSP(7a)

Isolation of the Film Responsible for the Passivity of an Iron Anode in Acid Solution. ULICK R. EVANS. *Nature*, Vol. 126, July 26, 1930, pages 130–131.

Anode films in H_2SO_4 solution may be removed from the iron by alternately making and breaking the circuit. (7a)

Electrolytic Deposits on Aluminum and Its Alloys. (Les depots electriques sur aluminium et ses alliages.) *Journal du Four Electrique*, Vol. 39, Mar. 1930, pages 96–97.

An abstract of the communication to the Academy of Science by M. Ballay. Al can be Ni-plated after flashing with Fe. Plating in cold solution containing 25–30 g. Fe and 6.5–9 mol. wt. of HCl per liter gives excellent adhering but strong tendency to rusting. Excellent results can be obtained with boiling solution containing 6–22 g. Fe and 0.10–0.70 mol. wt. of HCl per liter. JDG(7a)

Electrolytic Cadmium Plating as a Protection Against Rust. (Elektrolytische Kadmiumniederschläge als Rostschutzmittel.) B. PLANNER & M. SCHLOTTER. *Zeitschrift für Metallkunde*, Vol. 22, Feb. 1930, pages 41–47; *Doctor Thesis Technische Hochschule Darmstadt*, B. PLANNER (1929), 84 pages.

Experiments are conducted by the authors with the object of determining the most favorable conditions for electro-deposition of cadmium in order to secure the smallest crystal size, the densest and most uniform deposition in the thinnest layer with the maximum resistance against rust. The following factors exerting an influence upon the crystallization and the quality of the electro-deposited metal were studied: current density, motion of electrolyte, rise in temperature, acid concentration, addition of colloids and evolution of hydrogen. Cadmium was deposited from both alkaline and acid baths. The spray method is recommended as a short test on porosity. EF(7a)

The Electro-deposition of Metals from Their Liquid Ammonia Solutions. ROBERT TAFT & HAROLD BARHAM. *Journal Physical Chemistry*, Vol. 34, No. 5, May 1930, pages 929–953.

Electro-deposition of Pb, Ni, Cd, Cu, Ag, Zn, Cr and Al was studied from standpoint of chemical interest and possible commercial application. The factors of current density, metal ion concentration, hydrogen ion concentration, nature of anion, nature of the base metal, temperature, stirring and addition of colloids were considered. Lead deposits on an Fe base were comparable in some respects to those obtained from aqueous solutions. Good cadmium deposits were also obtained especially at room temperatures under increased pressure. The results obtained with the other metals were poor or entirely negative. The complete data are given in 6 tables and also numerous photographs of the deposits are reproduced. WHK(7a)

The Hardness of Electrodeposits. *Brass World*, Vol 26, June 1930, pages 159–161; *Journal Electroplaters' and Depositors' Technical Society*, Vol. 5, (1930), pages 63–82; *Metal Industry* (London), Vol. 36, Mar. 21, 1930, pages 321–323, March 28, 1930, pages 351–364, April 11, 1930, pages 410–412.

An abstract of a paper read by D. J. Macnaughton and A. W. Hothersall of Woolwich Arsenal before the Electroplaters' and Depositors' Technical Society. Methods developed for testing the hardness of metals are divided roughly into 2 groups: (*a*) indentation tests, and (*b*) abrasion or wear tests. Each type is briefly discussed. Brinell hardness ranges for lead, cadmium zinc, silver, copper, iron, nickel, cobalt and chromium are tabulated. Comparison of these with electrodeposits of these metals are noted, particularly in cases of nickel and chromium. A wide range of hardness is possible by adjustment of conditions of deposition. The author's abrasion test is as follows: specimens of circular section bright rolled mild steel 1 inch in diameter and 2 inches long were coated by electrodeposition to a thickness of about 0.02 inch with the metal under test. The specimens were then ground in a lathe to a fine finish and after careful weighing were mounted with their axes horizontal and revolved by means of an electric motor and reduction gearing at about 100 r. p. m. A weighted wooden block covered with sorbo rubber over which was stretched a piece of Hubert's O metallurgical paper was caused to move to and fro on the top of the revolving specimen. After a definite number of revolutions the specimen was removed, wiped clean and re-weighed. Results are tabulated in comparison with Brinell hardness of the deposits. No relationship exists but deposited metals fall into approximately the same order when classified according to their resistance to abrasion as when arranged according to Brinell hardness numbers. Ease of polishing, instead of being indicative of softness, is, in the case of nickel indicative of hardness with associated smoothness. The discussion is briefly reviewed. WHB(7a)

Electrometallurgy (7b)

Metallurgy of Zinc Produced by Electrolysis. (Metallurgie du Zinc par voie electrolytique.) J. VAN OIRBECK. *Journal du Four Electrique*, Vol. 39, May 1930, pages 169–172.

A historical review of electrolytic zinc produced since 1881. The main difficulty in electrolysis of zinc salts was the formation of a spongy zinc cathode. Zinc sulphate method consists in dissolving ZnO or any zinc ore, in dilute sulphuric acid, thus obtaining zinc sulphate, and from the solution, zinc is electrolytically deposited. Theoretically, one ampere hour deposits 1.2194 g.zinc or it takes 2000 kwh. per ton of zinc produced. In practice 95–96% of the theoretical value can be obtained. Two methods of electrolysis: weak and strong acid. Weak acid solution contains 60–120 g. sulphuric acid per liter and a current of 2–3 amperes/sq. dcm. being used; this method is mostly used in the U. S., Canada, Europe and Australia. Strong acid has 300 g. sulphuric acid per liter and 10 amperes/sq. dcm., method mostly used in France. GTM(7b)

METALLIC COATINGS OTHER THAN ELECTROPLATING (8)

Estimating Galvanizing Pot Life. WALLACE G. IMHOFF. *Iron Age*, Vol. 125, April 17, 1930, pages 1154–1155.

Shows rapid impairment of pots as temperature is raised. Pots heated to 1300° F. are destroyed in a very short time. A temperature of 950° F. the dissolving action is 9 times as active as at 900° F., and 16 times as active as at 850° F. Summarizes results of investigations as follows: (1) Temperature of bath is most important single factor influencing pot destruction; (2) Furnace design should be such that no part of pot where heat is applied should be heated above 900° F.; (3) Operating temperature of pot should not be above 875 to 885° F.; (4) Electric pyrometers should be used. Gives a number of tables and illustrations. VSP(8)

On the Chemical Methods for Testing Zinc Coatings of Sheet and Wire. (Ueber die chemischen Verfahren zur Prüfung von Zinküberzügen auf Blechen und Drähten.) E. H. SCHULZ. *Stahl und Eisen*, Vol. 50, July 17, 1930, pages 1017–1022.

Report of the Sub-Committee for Rust Protection of the Material Committee of the Verein deutscher Eisenhüttenleute. The known test methods to determine total amount, uniformity of and porosity of zinc coatings are considered, the results of comparison tests with various methods are tabulated and critically reviewed. Data were accumulated for hot and electro-galvanized wire (2 and 4 mm. diameter, respectively) as well as sheets of 1 mm. thickness with varying thickness of zinc coating. Short time test methods for examining corrosion resistance and the methods for distinguishing hot and electro-galvanized articles are described. The main conclusions are: (1) The uniformity of zinc coatings can be determined satisfactorily by a copper sulphate solution (1 Vol. Cu SO_4 to 5 Vol. H_2O), (2) The method of Bauer (sulphuric acid containing arsenic acid), Aupperle (hydrochloric acid + arsenous chloride) and Creutzfeldt are equivalent for determining the total weight of coatings. (3) All known test methods to determine the porosity of coatings are not reliable. (4) For corrosion-tests the method by Finkelday and the salt-spray test are suitable. (5) The method applied for coating can be tested by the practices of Bauer and Creutzfeldt. Hot galvanized coatings are indicated by both methods by the formation of cyanide salts. GN(8)

A Study of the Zinc Chloride Flux Used in the Manufacture of Tinplates. J. C. JONES. (University College of Swansea.) *Transactions Faraday Society*, Vol. 26, May 1930, pages 249–254.

Describes experiments which show that zinc chloride owes its fluxing properties to HCl formed by hydrolysis. Stannous chloride is present in flux due to attack of metal underneath and also by replacement of iron from its compounds by tin. Experiments also deal with practical aspects of tinning. Explains origin of "dross" or "hard tin" which collects at the bottom of the pots. LFM(8)

Zinc Coating of Iron and Steel. Report of Sectional Committee. *Preprint* 31, June 1930 Meeting, *American Society for Testing Materials*, 14 pages.

Proposed specifications for hot dipped zinc coatings on structural steel shapes, plates, bars and their products state that the impurity content of the zinc bath during galvanizing shall not exceed 1.60% Pb, 0.08% Fe or 0.01% Al. Cd is not specified. In a survey of baths in actual use Pb ranged from 0.96 – 1.10%, Fe from 0.04 – 0.06%, Cd from 0.63 – 0.73%, Al trace. Quenching of galvanized structural steel after it is taken from the zinc bath is permitted. No difference in properties of quenched or normally air cooled material were found, either as to coating or base, but retarded air cooling may cause peeling of the coating. In work on weight of coating it was found that 1½ min. immersion gave coatings averaging 2 oz./ft.² with some tests as low as 1.8. Rusted material took a heavier coating of zinc than similar un-rusted material. The specifications are, 2 oz. average, no individual specimen to show less than 1.8. Coupons attached to the work being galvanized were tried, but their indications were unreliable. Coating weight is to be determined by weighing actual specimens, which need not be over 3 ft. long, where inspection is made during galvanizing. If manufactured without inspection stripping tests are to be used. The Preece test may be used to determine uniformity but may not be used as a means of determining weight of coating. A moot point in drawing the specifications was the question of embrittlement. The specification states that "the finished material shall not be embrittled," but in a foot note it states that in the present state of the art embrittlement cannot be controlled, so that rejections for embrittlement are not to be enforced unless the liability is specifically provided for in the contract. The purchaser has to pay the cost of making embrittlement tests. Research to find the causes of and remedies for embrittlement is in contemplation. HWG(8)

INDUSTRIAL USES & APPLICATIONS (9)

Die Castings. C. H. GREENALL. *Bell Laboratories Record*, Vol. 8, June 1930, pages 468–472.

The manufacture of pressure die castings is briefly considered. Properties and applications of die castings to telephone apparatus is discussed. (9)

Wrought Iron—Some of Its Uses. J. S. TRINHAM. *Colliery Guardian*, Vol. 139, Nov. 29, 1929, page 2072; *Iron & Coal Trades Review*, Vol. 119, Nov. 15, 1929, page 754.

Discusses use of wrought iron in coal mine equipment. Used in suspension gear of mine-hoist cages, because of ability to cope with sudden shock and over-strain. (9)

Advantages of Chromium Plating. T. P. THOMAS. *Electric Journal*, Vol. 27, Aug. 1930, page 485.

An outline of usual and unusual applications of chromium plating. A thin deposit on sawblades for cutting slate and asbestos board has increased the life of the blades tenfold. WHB(9)

New Uses for Silver. JAMES BRINN. *Engineering & Mining Journal*, Vol. 129, June 23, 1930, page 621.

A letter suggesting the possibility of the use of high-copper-silver alloys, which respond to heat treatment in the same manner as duralumin, in trolley wires. These alloys rich in copper, should have greater strength and greater electrical conductivity, with superior properties as regards arcing. An alloy containing 99.5% copper, and 0.5% silver was used with favorable results, in trolley wheels. An investigation on the use of bronzes containing silver, as trolley wheel alloys should give valuable and interesting results. WHB(9)

Standard Specifications for High-Test Gray-Iron Castings. *American Society for Testing Materials, Standards-Supplement* (1929), pages 71–72.

The specifications given cover: scope, basis of purchase, process, transverse and tension tests, test specimens, number of tests, requirements, finish and inspection. (9)

Standard Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service. *American Society for Testing Materials, Standards-Supplement* (1929), pages 58–63.

The specifications given cover: scope, process, ladle analysis, check analyses, tension tests, hydrostatic tests, flattening tests, bend tests, test specimens, number of tests, retests, weights and dimensions, permissible variations, lengths, ends, finish, marking, inspection and rejection. (9)

Materials for Boiler Construction. (Werkstoffe für den Dampfkesselbau.) H. JUNGBLUTH. *Krupp'sche Monatshefte*, Vol. 11, July 1930, pages 177–184.

The author reviews the present state of the material problem in boiler construction and deals especially with the necessity of using materials not tending toward aging effects, and caustic brittleness. Izett steel is free of these difficulties. Alloy steels for boilers are furthermore reviewed and a simple method to test the creep limit approximately is described. In testing a group of steels containing chromium, managnese, molybdenum, vanadium, titanium, tungsten, copper and nickel, it resulted that molybdenum bearing steels in annealed condition have the best creep properties at 500° C. All steels containing Mo have a higher creep limit than those containing no Mo; they are superior to Ni-steels. Two types of Mo steels will probably be used most in the future: a steel 1% Cr, 0.5% Mo, low C and another 0.5% Mo. Finally the author reviews the application of the steels considered in the various parts of the boiler. GN(9)

Nickel and Its Uses in Engineering. W. T. GRIFFITHS. *Engineer*, Vol. 148, Nov. 29, 1929, page 590; *American Machinist*, Vol. 71, Nov. 30, 1929, page 177e; *Metal Industry* (London), Vol. 35, Nov. 29, 1929, page 508; *Nature*, Vol. 124, Nov. 23, 1929, page 823.

A lecture before the Junior Institution of Engineers. The lecturer drew attention to the number of new applications which have been developed for nickel and its alloys during the past decade, and outlined some of its uses which are of special interest to engineers. Examples were given of the value of nickel-containing materials in electrical, chemical, mechanical and railway engineering. (9)

Strength and Rigidity of Fixed and Rotating Machine Parts of Cast-Iron and of Welded Steel Construction. (Festigkeit und Starrheit von feststehenden und rotierenden Maschinenteilen aus Gusseisen und aus geschweissten Stahl-Konstruktionen.) KARL THIEN. *Elektrotechnik und Maschinenbau*, Vol. 48, May 4, 1930, pages 405–412.

Shows, by means of known values of the strength of materials and equations, as well as several practical examples worked out by the Aktiengesellschaft für Elektrische Industrie, that arc-welded steel constructions can be obtained with less material and will be stronger and more rigid than those of cast-iron. The weight of steel construction is, in general, only 1/2 to 1/4 that of cast iron. In spite of the necessary preparatory and welding labor welded steel construction is no more expensive than cast-iron. MS(9)

Pipe Welding Business Progresses. WEBSTER TALLMADGE. *Journal of the American Welding Society*, Vol. 9, July 1930, pages 86–89.

Gives illustrations and short discussion showing advantages of using welded piping in heating systems. LFM(9)

Frame Trusses, Roof and Piping to Be Welded in Albany Building. *Journal American Welding Society*, Vol. 9, July 1930, page 4.

Briefly describes new service building being erected by the New York Power and Light Corporation. By using welding methods about 30 tons of steel will be saved. A completely welded all-steel roof of the steel deck type is being used. All steel steam pipe above 2 inches in diameter will be welded. LFM(9)

Best for Rotary Kilns. *Oxy-Acetylene Tips*, Vol. 9, Aug. 1930, pages 13–17.

Advantages of oxwelded construction shown in fabrication of two 9 × 120 ft. kilns. Design and construction described in detail. MLM(9)

Turbo-Generator Rotor Shafts. W. SHARP. *Engineering*, Vol. 130, Aug. 1, 1930, pages 127–129.

Discusses various phases of rotor shaft design giving figures illustrating different types. Recommends using carbon steel in preference to 3% Ni steel. It is more difficult to obtain a solid forging with Ni steel. Best method is to proceed with the forging from the bloom. In this way inspection and testing can be carried out before forging. Describes the use of the borescope in detecting defects. Diagrams and photographs illustrating the various types of instruments are included. A table is given showing the mechanical tests given by forgings of normalized carbon steels and of an alloy steel oil-hardened and tempered. See also letter by A. P. Hague in the Aug. 15th issue on page 211. Mr. Hague favors the use of Ni steel for this purpose. LFM(9)

Aluminum Powder Used in New Material for Building. ALBIN H. BEYER. *American Metal Market*, Vol. 37, Aug. 12, 1930, page 4.

Fire, load and water tests on a new building material showed that after subjection for 4 hrs. to 1804° F. the surface temperature was increased but 11° F. The material consists of Portland cement, principally, with the addition of lime, and a small quantity of aluminum powder and soda. The new material is 66–75% lighter than concrete and extremely hard. WHB(9)

Tests Show Importance of Correct Babbitting. J. S. DEAN. *Electric Railway Journal*, Vol. 74, Aug. 1930, pages 532–533.

In general, the babbitt metals used in railway motors are divided into tin-base and lead-base alloys, which contain 80–90% of tin, or lead, respectively. The tin-base alloy is usually considered best for armature and axle bearings. Analyses are tabulated of 5 of each type of babbitt metal, also strength tests. One curve shows results of hammer tests of babbitt metals of various compositions and another curve shows the results of similar tests where the metal was poured under various conditions. The correct pouring temperature is highly important as is evidenced in the curves. The results of actual service tests of babbitt metals indicate that railway motor armature bearings, lined with an approved grade of either tin- or lead-base alloy will operate satisfactorily in service. WHB(9)

Iron and Steel Used in Electrical Engineering. L. E. BENSON. *Electrician*, Vol. 105, Part 1, July 11, 1930, pages 51–54; Part 2, Aug. 8, 1930, pages 170–173.

Attention is paid chiefly to materials used, primarily an account of their mechanical properties in the electrical industry. Gray cast iron, malleable iron, steel castings and fabricated parts are very briefly discussed. Tables show: properties of various typical engineering materials, composition and properties of cast and malleable irons, and physical test figures for high quality cast steel flywheels. Induction curves for various ferrous materials and several photomicrographs are included. The latter section deals with wrought materials—carbon steels, mild steel and wrought iron, alloy steels, the melting and casting of steel, forging and heat treatment. The bulk of wrought steel manufactured to-day is of the carbon steel variety. Physical properties of various wrought steels are tabulated, a few photomicrographs shown and uses of the various types of steel are mentioned. A composite photomicrograph on one side of a mild steel resistance butt weld shows the effect of heating on mild steel. WHB(9)

Steel House Construction. L. H. MILLER. *Preprint*, May 1930 Meeting, *American Iron & Steel Institute*, 7 pages; *Engineering*, Vol. 129, June 6, 1930, page 749.

Advocates steel flooring, frames, roof, partitions, etc. The adoption of steel instead of wood in house construction would lower building costs, increase fire resistance and open up a huge market to steel. HWG&LM(9)

Structural and Engineering Light Alloys for Aircraft. R. L. TEMPLIN, F. V. HARTMAN & E. C. HARTMANN. *Preprint* 33, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 7 pages.

Composition, heat-treatment, tensile, shear and endurance properties (also compressive strength for castings) are given for 6 wrought and 7 cast aluminum alloys. Data on the 7% Al, 0.4% Mn, 92.6% Mg alloy are given. In the heat treated condition this has as high strength as the strongest aluminum casting and a higher endurance limit. HWG(9)

Materials of Construction in Aircraft Engines. R. R. MOORE. *Preprint* 33, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 11 pages.

A radial air-cooled engine contains about 45% by weight aluminum alloys, 3% bronze, 52% steel. Composition, heat-treatment, properties and applications of a dozen Al and one Mg alloys for casting and forging in crankcases, cylinder heads, pistons, etc., are given. The low modulus of the Mg alloy is a drawback. There is a field for aluminum die-castings in unstressed parts. Data on 14 brasses and bronzes are given. For service under poor lubricating conditions a bearing bronze of 74% Cu, 5% Sn, 21% Pb is good. A nickel bronze 83 1/2% Cu, 10% Sn, 3% Pb, 3 1/2% Ni is good for gears, especially if chilled. The various steels and their applications are discussed. There is a wide divergence of opinion as to the selection of steel for valves. HWG(9)

More Metal Being Used in Planes. H. V. THADEN. (Pittsburgh Metal Airplane Co.) *Iron Age*, Vol. 125, Mar. 20, 1930, pages 858–860.

From conference of aeronautic division of the American Society of Mechanical Engineers and corresponding section of the Engineers' Society of Western Pa. held in Pittsburgh, March 12. The advantages of metal airplanes are: Their life is longer; they can weather outside storage; they are more fire resistant, their structure is more homogeneous and crash resistant and they lend themselves more readily to mass production methods. Three basic metals and their alloys being used for aircraft construction are steel, aluminum and magnesium. Magnesium sheet in thin gages presents problems of which fire resistance and corrosion are the most serious. Aluminum is being used in increasing extent both in the pure state and in various alloys such as duralumin and alclad. Steel has found extensive uses in aircraft from the medium carbon to the high alloy. For pure tension the best materials are alloy steels. For compression in short columns magnesium and aluminum alloys offer possibilities. The serious limitation on the use of either steel or duralumin sheets is the inability to use them in economical sizes because of the stiffness factor. VSP(9)

Ferrous Metals Used in Airplane Construction. J. B. JOHNSON. *Preprint* 33, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 7 pages.

Tail skid shoes are made of chilled cast iron or of steel or cast iron with a welded-on wear-resisting surface. Cast welding rods used are 4% C, 6% Mn, 1% Si, 30% Cr or 3 1/2% C, 16% W, 10% Cr. Manganese steel is not useful. S. A. E. steels, with properties and the uses to which they are put in aircraft are listed, tables being given for rods, bars and billets for drop forgings and machined parts, sheets and strips, tubes, also for sizes and breaking loads of aircraft cable. Brief comment is given in the text on all these. HWG(9)

Chromium Plating Finds Increased Use in Textile Industry. E. R. GRANGER. (Chromium Corp. of America.) *Textile World*, Vol. 77, June 21, 1930, page 51.

Discusses the most efficient uses of chromium plated articles in the textile industry. GN(9)

Medium Manganese Steel for Seamless Tubing. E. E. THUM. *Iron Age*, Vol. 125, April 10, 1930, page 1075.

Old specifications of A. P. I. were classified as "low carbon," "medium carbon" and "high carbon," but since 1926 designations for seamless varieties are:

Analysis	Grade A	Grade B	Grade C
Manganese	....	0.35 – 1.50	0.35 – .150
Minimum physical properties:			
Tensile strength	48,000	70,000	75,000
Yield Point	30,000	40,000	45,000
Elongation in 2 in.	40	25	20

Grade A is roughly equivalent to lap welded pipe, whereas Grades B and C are tested at pressures approximately 25% higher. Carbon content is unspecific. Steel similar to Grade C is used in Great Britain for tubing for aircraft, a service for which chrome-molybdenum tubing is used in U. S. British Engineers prefer medium manganese analysis on account of higher yield points and minimum tendency to air-harden at weld. In U. S. air-hardening of chrome-molybdenum tubes after welding is an advantage. Tabulates comparative specifications. VSP(9)

Applications of Stampings, Forgings and Castings in Aircraft Construction. H. G. RUNDE. *Preprint* 33b, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 11 pages: *Engineering*, Vol. 130, Aug. 29, 1930, page 282.

Illustrated description of aircraft fittings that can be made up in various ways. Cost of production of a few parts for experimental use and of large numbers of the same part governs the method of manufacture. Forgings and stampings are generally preferred for mass production. LM+HWG(9)

HEAT TREATMENT (10)

Small Parts Heated on Time Schedule. WIRT S. SCOTT. (Westinghouse Electric & Mfg. Co.) *Iron Age*, Vol. 125, April 24, 1930, pages 1214–1216.

Describes method employed by Black & Decker Co., Towson, Md. 95% of heat treating dept. is electrified with small electric furnaces. One-half in. electric drills constitute approximately 15% of total production. Parts, heat treated consist chiefly of Cr-Ni and Cr-V steels (S.A.E. 3140 and 6145). Heat treatment consists of hardening and tempering all parts, plus a certain amount of carburizing on gears and pinions. Definite heating cycles established in advance. Quality is improved and cost reduced with electric furnaces. VSP(10)

Electric Heating of Metals. (Ein Erhitzungsverfahren für Metalle auf elektrischen Wege.) F. STABLEIN. *Stahl und Eisen*, Vol. 50, Feb. 27, 1930, pages 263–264.

Stäblein describes Paul Hohl's method of heating metal pieces under water covered by German patent No. 72,802, class 11 and described in detail by the inventor in *Electrical Review*, Feb. 1, 1929, pages 185–187, and Feb. 8, page 229–231. This method, though already described by Hoho in 1892 remained rather unknown up to the present time but evidently offers interesting possibilities. The description of the phenomena and the effects produced have been recently confirmed by investigations of the Kaiser Wilhelm Institut für Eisenforschung. The method seems to be especially qualified for surface hardening as for instance hardening of the heads of steel rails. GN(10)

Continuous Furnaces for Normalizing. E. S. LAWRENCE. *Iron & Coal Trades Review*, Vol. 120, Mar. 7, 1930, page 409; *Transactions American Society Steel Treating*, Vol. 17, June 1930, pages 784–797.

Abstract of a paper read before the American Society for Steel Treating. See *Metals & Alloys*, Vol. 1, May 1930, page 525, "Continuous Heat Treatment of Sheet Metal." RHP(10)

Heat Treatment of Aircraft Parts. H. C. KNERR. *Preprint* 33d, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 15 pages.

General discussion. Properties of various S. A. E. steels under different heat-treatments are tabulated. For Cr Mo aircraft steel 4130X, Knerr advocates 1575–1625° F. for normalizing or quenching, and 1275–1375° F. air or 1375–1425° F. furnace, for annealing. On oil-quenching, and tempering at 680–1100° F. yield points from 180,000–110,000 lbs./in.^{2} are obtained. Types of furnace equipment for various heat treatment operations are discussed. HWG(10)

Salisbury Lowers Hardening Costs by Using Electric Furnaces. W. S. SCOTT. *Automotive Industries*, Vol. 61, Nov. 9, 1929, pages 681–683.

Description of method employed by Salisbury Axle Co., in manufacture of automobile axles. See *Metals & Alloys*, Vol. 1, Mar. 1930, page 428. (10)

Annealing (10b)

A New Method of Bright Annealing. R. W. MILLER. *Iron Age*, Vol. 125, April 3, 1930, pages 1002–1004; *Iron & Steel Industry*, Vol. 3, Mar. 1930, pages 181–183.

Describes Grunewald system of bright annealing installed by the Brown, Boveri & Co., Ltd., Baden, Switzerland. The annealing pot is rendered air tight when maximum temperature is reached to protect metal during cooling part of annealing cycle. Grunewald pot differs from other types in that it is suspended inside the furnace from the top. Following are the advantages of the system: (1) The hot annealing pot is stressed only by its own weight, therefore, it does not need to be strong and bulky. (2) Seal of annealing pot is not in contact with source of heat, therefore an air-tight joint can be made easily. (3) Part of heat stored in charge and in pots can be recuperated. Treating metals which oxidise at very low temperature, it is necessary to remove all oxygen from the pot. Glowing charcoal is used before sealing the pot. Metals which have been bright annealed by this method can be machined better and heat treated more accurately. VSP(10b)

Case Hardening & Nitrogen Hardening (10c)

Nitrided Steel. Measuring the Hardness and Thickness of the Case. E. G. HERBERT. *Mechanical Engineering*, Vol. 52, June 1930, pages 597–600. 14 references.

The author tested the application of his differential hardness test method to 8 different nitrided steels of the average composition: C 0.26–0.31%, Si 0.20–0.35%, Mn 0.50–0.60%, Al 1.0–1.20%, Mo 0.15–0.25%. The results are tabulated and presented in diagrams. GN(10c)

Nitriding of Steel in Electric Furnace. (La Nitruration des Aciers au Four Electrique.) DAUBOIS. *Journal du Four Electrique et des Industries Electrothermiques*, Vol. 39, April 1930, pages 133–134.

Steel used for nitriding process must have the following composition; 0.20–0.40% C, 1–2% Al, about 2% Cr, 0.50–1% Ni and 0.30–0.50% Mo. A nitrided steel forms an outer layer of Fe_2N and a second layer of Fe_4N. Aluminum reduces the penetration depth of nitriding. Nitriding process is carried for 90 hours at 500–525° C. in ammonia atmosphere and a 0.8 mm. thick hard layer is produced. Molybdenum is used in this type of steel in order to eliminate the brittleness. GTM(10c)

The Protective Action of Coatings for Partial Surface Hardening on Carburizing. (Ueber die Schutzwirkung von Abdeckmitteln gegen Zementation bei teilweiser Oberflächenhärtung.) OTTO ACHILLES. *Mitteilungen Forschungs-Institut Vereinigte Stahlwerke Aktiengesellschaft Dortmund*, Vol. 1, No. 10, 1930, pages 281–296. 20 references.

Investigations made on the protective effect of coatings against carburizing of steels, by electrolytic deposition of metals, mineral coverings and powders showed that; of the metals, such as Cu, Ni, Zn, Sn, Pb and Sb tried for this purpose, only Cu proved to be economical and suitable as a protective agent. The best protective effect of mineral covers is obtained when using a mixture of 42% sand, 44% clay, 10% borax, 2% sodium nitrate and 2% lead oxide. As powder coverings were used, smudge, bessemer dust, burnt lime, fresh lime and quartz sand. Of these the best ones are the smudge and the bessemer dust. But the most reliable protective effect is obtained by a metallic coating, electrolytically deposited on the parts to be protected against carburizing. GTM(10c)

Case-Hardening Practice for Tractor Gears. J. FLETCHER HARPER (Allis-Chalmers Manufacturing Co.) *American Machinist*, Vol. 72, Mar. 13, 1930, pages 449–452.

Describes the equipment and operation of the heat treating department of the Allis-Chalmers Manufacturing Co. The equipment is largely electrical. RHP(10c)

Quenching (10d)

Some Notes on the Behavior of Carbon Tool Steel on Quenching. G. V. LUERSSEN. *Transactions, American Society for Steel Treating*, Vol. 17, Feb. 1930, pages 161–198.

Includes discussion. The writer reports that as a result of about 5 years research it was found that certain common defects of carbon tool steel such as the tendencies to crack or develop soft spots in quenching or to check very readily in grinding are dependent, within certain limits, upon 2 properties, namely, hardness penetration and quenching range. The control of these factors in manufacture is not discussed. Hardness penetration is not dependent upon the analysis within the limits usually set, except that steels of around eutectoid carbon percentage harden deeper than those of higher carbon content. Neither is hardening range dependent upon the analysis but it is found that steels of a narrow hardening range have deep hardness penetration while those of a wide range may be either deep or shallow hardening. For the study of these properties a modified Metcalf test in which the specimen was split longitudinally instead of transversely is described. A temperature gradient of from 1200–1700° F. was generally used. It was further found that steels which are abnormal as determined by the standard McQuaid-Ehn test show relatively greater freedom from the defects enumerated above than do steels which are normal in this test, the abnormal steels having a much wider quenching range and average hardness penetration. A word of caution is given relative to the application of these terms for carburizing steels to tool steels. See *Metals & Alloys*, Vol. 1, Jan. 1930, page 344. WHK(10d)

Aging (10f)

Effect of Storing in Ice on the Aging of Duralumin. (Einfluss des Lagerns in Eis auf die Veredelung von Duralumin.) K. L. MEISSNER. *Metallwirtschaft*, Vol. 9, Aug. 1, 1930, pages 641–642.

Duralumin alloys are aged in several days at room temperature, and this action is hastened at elevated temperature. An investigation was made to determine whether the aging is slowed up or suppressed in ice water. Test pieces of No. 681 B 1/2 and 681 ZB 1/2 alloys were heated to 510° C. and quenched in water. One group was tested at once, a second after aging 2 and 5 days, respectively, at room temperature and a third after aging 2 and 5 days in ice. Curves show the results of tensile, yield point and elongation tests. At room temperature the aging is almost complete after 2 days, the tensile and yield point increasing and the elongation decreasing. In ice water the aging is slower and continues after 2 days, but does not reach the same point within 5 days as at room temperature. A second test was made continuing the aging for 20 days. After this period the properties of metals aged at both temperatures are practically the same. It is noted that the elongation decreases rather rapidly during the first 3 days and the increases slightly. CEM(10f)

The Artificial Ageing of Duralumin and Super-Duralumin. K. L. MEISSNER. (Dürener Metallwerke A. G.). *Institute of Metals, Advance Copy* No. 533 (1930) 28 pages. 15 references.

Duralumin type alloys were artificially aged by heating to slightly elevated temperatures, one series immediately after quenching and the other series after having been aged at room temperature. There was little difference in hardening between the 2 series. With increasing aging temperatures the Brinell hardness, yield point and tensile strength fell to a minimum at about 125° C., after which they continued to rise to a maximum at about 170° C. The rise in yield point is very pronounced while the hardness and strength change only slightly. The elongation, reduction of area and flexibility are relatively unaffected at the lower temperatures, but fall to low values at about 200° C. Artificial aging of cold rolled age-hardened material removes the effects of cold rolling, and an aging at 100 or 125° C. yields a material with a high yield point and high tensile strength combined with a high elongation. This combination of properties cannot be obtained by any other method. The compounds responsible for age-hardening in Duralumin and the possible mechanism of their precipitation are discussed. The "super-Duralumin" developed by Jeffries and Archer was also studied and it was found that the increase in hardness resulting from aging at high temperatures was greater than that for Duralumin. The "super-Duralumin" differs chiefly in that it contains more silicon. JLG(10f)

JOINING OF METALS & ALLOYS (11)

Metal Joints in Aircraft Construction. T. W. DOWNES. In *Preprint 33, Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 13 pages; *Engineering*, Vol. 130, Aug. 29, 1930, page 282.

Procedure used in welding, brazing, soldering and riveting, at the Naval Aircraft Factory. Cr Mo steel is in favor not only because of its good strength in heat treated welds, but also for ease of welding. Ni steels are avoided for welding because of inferior properties of joints. Welding unlike steels together is discouraged. In welding Al alloys, welding rod containing 5% Si is useful. Dip brazing is described in detail. Brazed joints are tight. Moisture does not penetrate and hence resistance to corrosion is good. Nickel steels tend to crack on brazing. Soft soldering and silver soldering are dealt with. Soldered joints in aluminum are liable to rapid corrosion and may not be used to carry stresses. LM+HWG(11)

Soldering (11b)

The Jointing of Metals Part 1, Soft Solders and Soldered Joints. S. J. NIGHTINGALE. *Research Reports, British Non-Ferrous Metals Research Ass'n.*, No. C 234–214, Dec., 1929, 96 pages, 44 figs., 10 sh.

Report of 7 year's research. Great emphasis is placed on the effect of Sb in SnPb solders. According to the British Engineering Standards Association Specification No. 219, of 1925, 9 grades of solders are specified, as follows: A (low melting point, for steel tube joints), 65% Sn, 1% max. Sb; B (for fine work and bit soldering), 50% Sn, 2 1/2 – 3% Sb; C (for general work), 40% Sn, 2 – 2.4% Sb; D (for plumbers' wiped joints), 30% Sn, 1 – 1.7% Sb; E (for special electrical purposes), 95% Sn, not over 0.5% Sb; F (for general electrical purposes and galvanized iron), 50% Sn, not over 0.5% Sb; G (for dipping baths, galvanized iron and tinned electrical joints), 42% Sn, not over 0.4% Sb; H (for lead cable wiped joints), 35% Sn, not over 0.3% Sb; J (for dipping baths), 30% Sn, not over 0.3% Sb. All except grade E allow a variation of ±1% in Sn, grade E, ±0.5%. Maximum impurities in all grades are 0.25% with Fe max. at 0.02% and As max. at 0.05%. The solders are considered on the eutectic basis, 63% Sn, 37% Pb being 100% binary eutectic. Pb is practically inert as a solvent for Sb, while Sn can hold approximately 6% of Sb in solid solution. If more Sb than the ratio 94 Sn : 6 Sb is present, whatever the Pb content, the γ-constituent of the Sn Sb system appears and the alloy is useless as solder. Within that limit, the effect of Sb is set forth in detail. The effect of Sb within that limit, upon the melting point is so slight as to have no practical effect on the use of the solders. The effect of Sb on the strength of solder is very marked. Additions of 3 and 6% Sb to Sn raise the tensile strength from about 2000 to 4400 and 7200 lbs./in.^{2} A considerable ratio of increase holds for the addition of Sb to the Sn Pb solders. The highest strength in Sb-free solder is at 75% of the Sn Pb eutectic, with 25% excess Sn, about 8000 lbs./in.^{2} Addition of Sb in the ratio of 6 Sb : 94 total Sn raises it to 10,300 lbs./in.^{2} Increase in strength is nearly proportional to amount of Sb. Ductility is decreased by Sb, but a Sb : Sn ratio of 6 : 94 causes very little more decrease than one of 3 : 97. The maximum in the strength curves and the maximum and minima in the ductility curves, all come at the same Sn : Pb ratio, irrespective of the presence of Sb. Minima of ductility are at the ratio of maximum strength (75% Sn Pb eutectic, 25% excess Sn) and at 50% Sn Pb eutectic, 50% excess Pb, but the maximum ductility comes at 75% Sn Pb eutectic, 25% excess Pb. Using Sb in the 94 Sn : 6 Sb ratio drops this maximum ductility from 45–35%, and the 2 minima from 30–15% , and from 25–20% respectively. The B. E. S. A. grade C alloy with 40% Sn, 2.4% Sb has 7800 lbs./in.^{2} tensile, 34% elongation. Maximum shear strength is at 100% Sn Pb eutectic, and is raised by Sb. Maximum impact strength is at 90% eutectic, 10% excess Pb (grade B) with grades A and C very nearly the same as B. Impact is scarcely altered at all by presence of Sb up to a Sn : Sb ratio of 97 : 3, while increase of Sb to the 94 : 6 ratio drops the impact strength from around 15 ft. lbs. to about 11. Hardness, density and electrical conductivity curves are given. Maximum joint strength was obtained in copper with a joint thickness of 0.003", soldered at 300° C. using grade B solder containing Sb. With brass, the joint strength was about the same whether Sb was present or not. With mild steel, the Sb-free solders showed slightly higher strength and grade C was as strong or stronger than grade B. Methods of testing soldered joints, the metallography of joints and the question of alloying with the material soldered, are discussed, as is the question of corrosion. From the practical point of view, grade C solder, 40% Sn, 2.4% Sb, 57.6% Pb gives best all-round properties unless maximum fusibility is required, in which case, about 60.9% Sn, 3.3% Sb, 35.8% Pb is the best. However, if galvanized ware is to be soldered, Sb is to be avoided, as Sb and Zn are incompatible. In dip-soldering of brass and Cu, the Sb content is best held at 1% of the Sn content, as higher or lower amounts increase drossing. For electrical work, 94% Sn, 6% Sb is advocated, while for tinning of Cu absorption of Cu by the Sn bath should be minimized by holding the bath at 50–60° C. above the melting of tin, and using 95% Sn, 5% Pb, where solders containing lead are to be used. But if subsequent soldering is to be done by pure Sn or 94% Sn, 6% Sb, the tinning bath should contain 99% Sn, 1% Sb. Sb up to 6% of the Sn content (Sn not below 31%) is advocated for wiping solder. The best flux for soldering is one of eutectic proportions of $ZnCl_2$ and NH_4Cl, melting at 179° C., and permitting soldering at 200° C. Cast iron is best tinned after pickling cold in 5% HF 15 minutes, covering the molten Sn with fused $ZnCl_2$, and holding the bath slightly above 262° C., the melting point of $ZnCl_2$. The pickling reduces the C content at the surface of the iron. Cast iron low in C and in S tins easiest. B. E. S. A. grade H solder for lead cable wiped joints, 35% Sn, 0.3% max. Sb would be improved by making it 30.5% Sn, 1.8% Sb. The other grades are considered good for their respective purposes. In general, the presence of Sb in solders, save those for use on galvanized iron is considered advisable both on the score of properties of the joints and of cost. HWG(11b)

A Soldering Process for the Manufacture of Cylinder-Heads of Steel for Diesel-Engines. (Ein Loetverfahren zur Herstellung von Zylinderdeckeln aus Stahl für Dieselmotoren.) Fr. Sass. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Dec. 21, 1929, pages 1811–1814.

A new method of K. Bassler is described which makes it possible to build up cylinder-heads of different steel parts which are soldered together with a special solder. The advantage is seen in the better qualities of steel over cast-iron and in the possibility of giving the steel parts such a shape that inner stresses are avoided. Such cylinder-heads are in satisfactory operation for more than a year. Ha(11b)

Soldering Tungsten. R. d'E. Atkinson. *Nature*, Vol. 126, July 19, 1930, page 97.

Metals may be soldered to W with Au, Pd, Zn, high Zn brasses, German silver and Ni. Borax is a suitable flux for all the metals. No flux is necessary with Pd. For general use, the best method is to apply Au, using an oxy-coal gas flame and borax; then wrap with Pd wire round the Au, apply fresh borax and reheat till the Pd has melted into the Au. (11b)

Welding & Cutting (11c)

Influence of Pressure in the Oxy-acetylene Burner on the Economy and Quality of Welding. (Einfluss der Druckverhältnisse im Azetylen-Sauerstoff-Schweissbrenner auf die Wirtschaftlichkeit und Güte der Schweissung.) Hugo Kemper. *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, March 22, 1930, page 360.

This article is an extract from the Doctor thesis of the author and deals with the most favorable pressure of acetylene in welding burner. After describing the arrangement of a measuring and testing arrangement the following conclusions are drawn. (1) The ratio of the mixture is variable in all burners tested due to an increase of pressure in the burner pipe caused by heating. Injector burners show an increase of consumption of acetylene of 2–3% with high-pressure and from 20–30% for low-pressure apparatus. The minimum acetylene pressure should, therefore, not be less than 1 to 3 in. water gage. (2) All burners show back-firing but this seems to have no relation to pressure conditions. (3) The variation in the ratio of the mixture can be eliminated to a great extent by cooling of the mouthpiece of the burner. (4) The output of a burner depends on the velocity of the escaping gas; it is a maximum at about 190 m./sec. for machine welding and about 130 m./sec. for manual welding. The pressure seems to have no influence. (5) Also on the quality of the welded seam the pressure seems to have no influence. Ha(11c)

Electrically Welded Iron Structures. (Elektrisch Geschweisste Eisenkonstruktionen.) E. Rosenberg. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Dec. 7, 1930, pages 1742–1746.

In this article some preliminary tests are described for the construction of an electrically welded railroad bridge and the method of design which was recommended by the experts. Suggestions are made which make full utilization of the advantages pertaining to electric welding. The results of load tests are given and the arc-welded construction of a big hall 320 ft. long and 40 ft. wide described. Ha(11c)

Shape-Cutting in the Machine Shop. *Oxy-Acetylene Tips*, Vol. 9, Aug. 1930, pages 4–5.

Various uses have been found for automatic oxyacetylene shape-cutting machines in manufacturing plants. They can be used for making tools and accessories as required. MLM(11c)

Fusion Welding as Applied to Railroad Work. Frank Longo. (Southern Pacific Railroad.) *Journal American Welding Society*, Vol. 9, July 1930, pages 82–86.

Paper presented before the Los Angeles section of the American Welding Society, May 29, 1930. Describes various welding processes involved in making heavy repairs on locomotives and tenders. LFM(11c)

Metals and Welding. W. B. Miller. (Union Carbide and Carbon Research Laboratory.) *Journal American Welding Society*, Vol. 9, July 1930, pages 98–104. 5 references.

Paper presented before the New York section of the American Welding Society, Dec. 10, 1929. Classifies the commercial alloys into ferrous and non-ferrous groups and into types according to composition. Discusses weldability based on the properties of the alloys and metals entering into their composition. A partial list of trade names of various ferrous and non-ferrous alloys with their approximate composition is given. LFM(11c)

Gas Welding in the Aircraft Industry. C. E. Kirkbride. *Modern Machine Shop*, Vol. 2, Mar. 1930, pages 54–61.

Oxy-acetylene welding has become the standard method of steel fabrication of commercial aircraft especially in the making of the fuselage. MLM(11c)

Welding in Machine Construction. (Schweissen im Maschinenbau.) H. Neese. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Dec. 7, 1929, pages 1738–1739.

The possible advantages in saving of weight and use of steel as against cast-iron, as also saving in labor and time, are discussed in general and illustrated by a few striking examples. Ha(11c)

Electrical Butt-Welding, Possibilities in Ship-Building. (Die elektrische Stumpfschweissung [Abschmelzverfahren], Anwendungsmöglichkeiten im Schiffbau.) Th. Wuppermann. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Dec. 7, 1929, pages 1758–1763.

Flame-welding does not always give reliable and certain results. The use of electric butt-welding by melting instead of the former method gives entirely reliable results and can particularly be recommended for ship-building. A great number of illustrations of tests results and micro-photographs are given and in the discussion of this paper these results are corroborated by several speakers. Ha(11c)

Welded Constructions in the Building of Aeroplanes. (Geschweisste Konstruktionen im Flugzeugbau.) Alfred Koppenhoefer. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Dec. 7, 1929, pages 1727–1730.

The author describes in particular the construction of the Ernst Heinkel Flugzeugwerke which consist in carrying surfaces of wood while the other parts, fuselage, body, motor supports, etc., are made of welded structures. The latter are described in detail and the properties of the materials used and the welded constructions are discussed; the principal advantages and disadvantages are then considered. Ha(11c)

Arc Welded Boilers Not Far Off. G. E. Koch. (Westinghouse Electric & Manufacturing Co.) *Electrical World*, Vol. 96, Aug. 16, 1930, page 306.

The author states that boiler manufacturers are watching results of arc welding in oil-cracking stills and similar apparatus dealing with higher pressures and temperatures than are common in boilers. Manual and automatic welding speeds are compared. The development of the automatic welding head has contributed largely to the greater reliability and consistency in arc welding. WHB(11c)

Bronze Welding Rod and Its General Use on Metals. P. W. Blair. *Metal Industry* (London), Vol. 36, Mar. 7, 1930, page 273.

Bronze welding is used for joining by fusion all types of brass, bronze and copper alloys; also for joining dissimilar metals. The advantage of bronze weld metal is that bronze alloys easily with bronzes or brasses, and joins by adhesion with steel, iron and other metals at temperatures below melting points of these metals. For fusion welding high strength bronze welding rods are used. VSP(11c)

Electric Welding of Mild Steel by the Metal Arc Process. V. G. Pearson. *Edgar Allen News*, Vol. 9, Aug. 1930, pages 673–675.

Stresses the necessity of training operators slowly and carefully. The work should be well prepared before welding. MLM(11c)

Copper Welding, Especially of Locomotive Fire-Boxes. (Die Kupferschweissung insbesondere an Lokomotivfeuerbüchsen.) Richard Samesreuther. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Dec. 7, 1929, pages 1731–1732.

The 2 methods of riveting and welding of copper boilers of locomotives are compared and the latter given decided preference, especially as the material can be shaped much more suitably to avoid stresses. Certain rules and precautions, however, must be observed, which are described in detail and concern proper selection of material and manner of procedure during welding. Ha(11c)

Influence of Impurities in Oxygen and Acetylene upon Welding. (Einfluss der Verunreiningungen im Sauerstoff und im Azetylen auf das Schweissen.) W. Rimarski. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Oct. 12, 1929, pages 1467–1468.

It has been experimentally determined that the efficiency of the oxy-acetylene flame depends to a large extent on the purity of the 2 gases used together. Tests were made on sheets of 4 mm. thickness, the cutting-pressure (of the gas) was varied between 1 and 4 kg./cm.², and the purity of the oxygen was 97.5 to 99.5%. It was shown that with increasing consumption of oxygen the time for cutting 1 m. length of material decreases; for example, oxygen of 99.5% purity and 1.6 kg./cm.² pressure required 4.4 min. and consumed 124 liters oxygen, with 4 kg./cm.² 2.75 min. and 143 liters. For a purity of 97.5% and 2.4 kg./cm.² the time was 4.7 min. and consumption 182 liters, while with 4 kg./cm.² the respective figures are 3.75 min and 194 liters. Regarding economy the high-grade oxygen takes first place. The cutting time can be shortened by pre-heating the oxygen, but this effect depends to a certain degree on the manner of pre-heating. Presence of nitrogen increases the cutting-time, but does not influence the quality of the welded seam. Ha(11c)

Two Interesting Failures of Welded Patches on Large Steel Pipe. W. W. Brush. *Water Works Engineering*, Vol. 83, July 2, 1930, pages 1013–1014.

The paper describes 2 separate cases in which the welds on small coupon patches in large steel pipes failed. GN(11c)

New Experiences with Electric Arc Welding. (Neuere Erfahrungen mit der elektrischen Lichtbogenschweissung.) K. Jurczyk. *Stahl und Eisen*, Vol. 50, June 12, 1930, page 834–840.

The author exemplifies how stresses in welding can be decreased by applying certain precautions thus giving high-grade welds. Among the items to be taken into consideration are the construction itself, the relation between the toughness of the welding and the cooling rate, the attachment of the counter-electrodes and their moving speed are especially emphasized. The advantages in applying the arc welding method are considered for railroad and machine construction. GN(11c)

Resistance Welding. R. T. Gillette. (General Electric Company.) *Journal American Welding Society*, Vol. 9, July 1930, pages 77–82.

Paper presented before the New York meeting of the American Welding Society, March 11, 1930. Considers following types of resistance welding giving examples of each group: spot, projection, line, butt, resistance annealing, flash and resistance soldering and brazing. Fully illustrated. LFM(11c)

Aims and Limits of Welding. (Ziele und Grenzens des Schweissens.) Fueschel. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Dec. 7, 1929, pages 1725–1726.

Technical, economical and psychological motives in the development of welding are discussed and the influence of the process on the choice of material and shape of sections for the members to be combined is investigated. A welding process must be carried out in such manner that any internal stress is avoided and at the same time as little as possible material used. Examples for these aims in both industry and art-craft are given. Ha(11c)

Progress in the Application of High-grade of Welding Wire. (Fortschritte in der Verwendung hochwertiger Schweissdrähte.) F. Sommer. *Zeitschrift Vereins deutscher Ingenieure*, Vol. 73, Dec. 7, 1929, pages 1764–1768.

Discussion of physical and metallurgical properties of a few new welding wires for electric welding. Ha(11c)

Welded Crane Trolleys. (Geschweisste Drehlaufkatzen.) L. Schulze. *Zeitschrift Vereins deutscher Ingenieure*, Vol. 73, Dec. 7, 1929, pages 1755–1758.

Description of tests and construction of a 12.5 ton rotating crane of "Union Baustahl." Ha(11c)

Tests with Welded Girders; Application of Electric Welding in Bridge-Building. (Versuche mit geschweissen Fachwerkträgern, Anwendung der Elektroschweissung im Brückenbau.) W. Gehler. *Zeitschrift Vereins deutscher Ingenieure*, Vol. 73, Dec. 7, 1929, pages 1747–1755.

The author discusses first how the quality of electric welding in structures is best judged and gives the results of some tests on girders of different shapes. He gives suggestions for possible reinforcement of steel structures. Ha(11c)

Welding in Railroad Construction. (Schweissen im Eisenbahnwesen.) Bardtke. *Zeitschrift Verein deutscher Ingenieure*, Vol. 73, Dec. 7, 1929, pages 1733–1737.

A very wide field of application for welding is offered in all matters of railroad construction, both in repairing and making of new parts. Illustrations are given of the many various possibilities. Ha(11c)

Welding Cast Iron. W. Steel. *Foundry Trade Journal*, Vol. 42, Mar 13, 1930, pages 195–196.

Paper read before joint meeting of London branch of the Institute of British Foundrymen and Institute of Welding Engineers and British Acetylene Association. An autogenous weld on cast iron should equal the original section. Softness of weld metal is essential. Procedure in its proper sequence is as follows: (1) Remove all foreign matter from weld area; (2) preheat the casting; (3) add correct filler metal which is silicious and free from Mn; and (4) allow casting to cool slowly. The four autogenous processes are: Burning on, electric arc, oxy-acetylene and thermit. Considers bronze welding. VSP(11c)

Arc Welding of Stainless and Corrosion Resistant Steels. R. D. Thomas. (R. D. Thomas & Company.) *Journal American Welding Society*, Vol. 9, July 1930, pages 90–98; *Iron Trade Review*, Vol. 86, June 19, 1930, pages 59–62.

Paper read before the Philadelphia section of the American Welding Society, May 19, 1930. Briefly describes various types of corrosion resistant steel. Tables are given showing typical analyses of Cr-Ni alloy steels and stainless irons. Physical properties of 18/8 alloys and of 14% straight Cr iron are given. Both low and high carbon 18/8 alloys can be easily welded but the latter must be annealed after welding to obtain maximum corrosion resistant qualities and necessary ductility. Heat resisting alloys of 18/8 and 2 to 3% Si or of 10% Cr and 24% Ni are easily welded. Gives details of welding procedure. A photomicrograph through line of fusion of 18/8 Cr-Ni deposit on 18/8 parent metal is given as well as numerous illustrations showing uses of various types of welded material. LFM(11c)

WORKING OF METALS & ALLOYS (12)

Melting & Refining (12a)

Aluminum. THOS. M. PUGSLEY. (Newcastle Alloy Co.) *Chemical Engineering & Mining Review*, Vol. 22, June 5, 1930, pages 327–329.

The growing use of aluminum is pointed out and 2 methods used in the U. S. A. of melting aluminum chips are outlined. One is the "puddling" process and the other is based on the same principle as that of welding aluminum, where fluxes, chlorides or fluorides of the alkalies or alkaline earths are used to dissolve the film of oxide and to allow the metal surfaces to unite. Care must be used in melting aluminum to guard against overheating or too prolonged heating. WHB(12a)

The Action of the So-Called "Deoxidizers" in the Manufacture of Steel. (L'Azione dei cosi detti "disossidanti" nella fabbricizione dell' accacio su suola. Nota II.) F. GIOLITTI. *La Metallurgia Italiana*, Vol. 8, June 1930, pages 640–648, 4 references.

A continuation of his study on the effect of deoxidizers on the transverse weakness, and a critical review of 3 papers by Benedicks & Löfquist, Hibbard & J. Seigle, showing the importance of deoxidation of steel with Mn and the type of non-metallic inclusions found in steel as related to the transverse properties of steel. GTM(12a)

Production of Electric Steel for Castings. GEORGE BATTY. *Transactions American Society for Steel Treating*, Vol. 17, Mar. 1930, pages 449–470.

Includes discussion. Paper before 11th Annual Convention, Sept. 1929. See *Metals & Alloys*, Vol. 1, Jan. 1930, page 344. WHK(12a)

Deoxidation in the Making of Steel. JOSEPH R. MILLER. *Iron Age*, Vol. 125, April 24, 1930, pages 1223–1224.

Function of deoxidizing agent is to remove injurious forms of iron oxide residual from normal steel making process. In mild "rimming" steel gaseous oxides are partially removed by effervescence. As ingot freezes certain amount of gas remains causing blow-holes. Teeming is regulated to seat blow-holes well within outer skin of ingot so they do not appear as surface defects. In top freezing size of blow-holes is reduced by means of pressure. Top freezing is accomplished by use of necked top molds and keyed caps, but sometimes Si or shot Al is used in top quarter. High C steels are often full killed, so that no gaseous elimination takes place. Deeper pipe results and less sound steel from ingot, but fewer blow-holes. If not deoxidized, ingots will not roll. Much of the steel which is bad is stopped at point of blooming due to development of defects. VSP(12a)

Electric Furnaces. N. RYLAND DAVIS & C. R. BURCH. *Electrical Review*, Vol. 106, June 20, 1930, pages 1171–1172.

Abstract of paper read before the Manchester Association of Engineers. See *Metals & Alloys*, Vol. 1, Mar. 1930, page 429. MS(12a)

Physical-Chemistry as a Means of Judging the Possibilities of Reaction in Steel Production. (Die Beurteilung der Reaktionsmöglichkeiten bei der Stahlerzeugung mit Hilfe physikalisch-chemischer Vorstellungen.) H. SCHENCK. *Stahl und Eisen*, Vol. 50, July 3, 1930, pages 953–966.

Report No. 188 of the Steel Mill Committee of the Verein deutscher Eisenhüttenleute, presented before the annual meeting, May 17, 1930 at Düsseldorf. Includes discussion. The course of chemical reactions in producing steel is limited by a "best value of utilization," which corresponds to the state of equilibrium. For this reason the "value of utilization" also determines the direction of reaction. The relations between the "best value of utilization," temperature and slag constitution are considered for the reactions of manganese, phosphorus and sulphur. The practical experiences and data of steel mills can be evaluated according to the established theoretical calculations. It depends very much on the actual conditions in producing steel to what extent the "actual value of utilization" approaches the "best value of utilization." The equations for the calculation of free FeO seem to be most satisfactory. Free FeO in the slag decisively influences the reactions of carbon and the solubility of FeO in the metal. The relations between FeO concentration in slag and metal are considered to be of great importance as to the relations between steel quality and production method. GN(12a)

Practical Observations on Manufacture of Basic Open-Hearth, High-Carbon Killed Steel. W. J. REAGAN. (Edgewater Steel Co.) *American Institute of Mining & Metallurgical Engineers, Technical Publication* No. 347 (1930), 16 pages, 5 references.

The best method of melting and casting forging steel containing from 0.50 to 0.85 % C is described. The steel is melted in an 80-ton furnace, preferably from only slightly rusty heavy scrap and a pig iron containing from 1 to 1.30% Si and at least 2% Mn. The charge should melt to give a carbon content necessitating the addition of ore. About 2 hours after the ore addition the heat is deoxidized with about 1500 pounds of spiegeleisen and the final deoxidation is made with ferromanganese about 10 minutes before tapping. The steel is bottom cast into duodecagonal molds that have been sprayed with a graphite mixture. Pouring speed and casting temperature is important as shown by data presented in the form of curves. The basic open-hearth steel has been found to make a forging steel at least as good as that produced in the acid open-hearth. JLG(12a)

Casting & Solidification (12b)

Cooling Phenomena of Copper-Tin Alloys. JOHN E. NEWSON. *Foundry Trade Journal*, Vol. 42, Mar. 6, 1930, pages 183–184.

Abstract of paper on "Non-ferrous Castings from a Metallurgical Point of View," read before the Middlesborough branch of the Institute of British Foundrymen. Emphasizes the importance of solidification of metal in mold. Numerous failures may be traced back to the changes that occur when molten metal freezes and cools down to temperature of mold. Melting range varies in non-ferrous alloys, and is an important factor in the casting qualities of alloys. Since there is a reduction of volume on cooling, to obtain sound casting,the freezing must be so controlled that liquid metal may be available at the last point of the casting to freeze. The strength of most non-ferrous metals, particularly Al-Cu-Zn alloys is very low just below the point at which it becomes solid. Sand with a very low bond is used. Considers hydrostatic laws and metal fluidity. VSP(12b)

Shrinking and Piping—Shrinkage. Problems of Iron, Steel and Metal Foundries. (Schwindung und Lunkerung—Schwindmass. Probleme der Eisen-, Stahl- und Metallgiesserei.) WILLI CLAUS. *Giesserei*, Vol. 17, May 9, 1930, pages 449–455.

A lecture, 2 micro- and 2 macrographs of an Al bronze (10% Al) are given. (12b)

Cast Aluminum Bronzes. I. Alloy Groups-Liquation Phenomena. (Gegossene Aluminumbronzen. I. Legierungsgruppen. Entmischungserscheinungen.) W. CLAUS & F. GOEDERITZ. *Giesserei*, Vol. 17, Feb. 14, 1930, pages 153–155, 182–186.

A study of the liquation in Al bronzes (4.4% Al–95.5% Cu, 7.1% Al–92.9% Cu, 10.5% Al–89.7% Cu, 10.16% Al–84.2% Cu, with traces of Mn, Fe, Ni, Sn and Pb) so cast in dry, moist and chill molds, that the long axis of the castings are either vertical or horizontal in the mold. In general the vertical castings show an increase in Cu from the top downward, while the differences in Cu content in horizontal planes between the outer and central zones decrease from top to bottom. With increase in pouring temperature there is a slight increase in horizontal liquation. Castings from horizontal molds show an improvement in liquation over those from the vertical. (12b)

Pouring Speed May Be Adjusted with Precision. H. W. DIETERT. *Foundry*, Vol. 58, Mar. 1930, pages 129–130.

Variation in cooling will result in case of slow pouring, in hard brittle castings, in case of those poured fast will result in castings with segregations and internal strains. Casting should be poured at a rate so as to cause a progressive freezing of the metal from the far end to the gate side of the casting. Gives formulae by which the correct time in which casting should be poured, effective sprue height above the choke and the area of the choke may be calculated. VSP(12b)

The Practical Importance of the Influence of Various Cooling Conditions on the Structure of the Steel Ingot. (Die praktische Bedeutung des Einflusses verschiedener Abkühlungsbedingungen auf das Gussgefüge des Stahlblockes.) F. LEITNER. *Stahl und Eisen*. Vol. 50, July 31, 1930, pages 1081–1086.

Paper before the annual meeting of the "Eisenhütte Oesterreich" at Loeben. The author gives some instances to show that an etching to develop crystals is most advantageous to judge the primary structure of an ingot. Smaller sections of the ingot lead, when etched, to erroneous conclusions. The influence of the wall thickness of various shaped molds on the transcrystallization of the edge of the ingot is revealed. As soon as the wall thickness exceeds a certain amount no differences in crystallization were found in the molds examined. This holds also for strongest water cooling of molds. The velocity of freezing for certain times was determined by studying the crystallization zones. These results were related to the results of the primary etching for chromium-nickel steels. A small wall thickness of the mold is preferable. Essential advantages in the crystallization of the ingot results from a slow cooling of the freezing ingot. GN(12b)

Influence of Casting Practice on Physical Properties of Die Castings. CHARLES PACK. *American Institute of Mining & Metallurgical Engineers, Technical Publication* No. 346 (1930) 14 pages.

Methods of processing as well as alloy compositions influence the properties of die castings. Proper control of cooling is even more important than in foundry work. Variations of over 25% in the physical properties of zinc base die castings have resulted solely from a change in the rate of cooling. As a rule the casting temperature should be as near the melting point as possible. The temperature of the die and the wall thickness of the die are important. The plunger type casting machine is now used for low melting alloys, but for aluminum and copper alloys the direct air pressure machine is required because the plunger usually "freezes" when used with alloys having a casting temperature above 850° F. The direct air pressure machine cannot be operated safely at pressures above 500 lbs./in.^{2} Machines of the plunger type are now being developed for use with aluminum and copper alloys, and the author expects to report on these machines in an additional paper. The type and size of the gate and vents influence the properties of the castings. The speed of operation is important, because shrinkage is liable to crack the alloys if they are left in the die too long. Other factors are also discussed. JLG(12b)

Rolling (12c)

Rolling Pressure and Power Consumption in a Zinc Rolling Mill. (Ueber Walzdruck und Energiebedarf in einem Zinkwalzwerk.) G. B. LOBKOWITZ. *Zeitschrift für Metallkunde*, Vol. 22, Jan. 1930, pages 8–13.

The author communicates his measurements on rolling pressure and efficiency in a Zn rolling mill and discusses in detail the computation of power required for such a plant. The mathematical derivation of the formulae applied are given and the practical results obtained are collected in tables and presented in graphical form. EF(12c)

Determination of Bevels to Avoid Fins in Rolling. (Bemessung von Abkantungen zur Verhinderung der Gratbildung beim Walzen.) W. TAFEL & W. KNOLL. *Archiv für Eisenhüttenwesen*, Vol. 3, June 1930, pages 745–749; *Stahl und Eisen*, Vol. 50, July 3, 1930, page 968–969.

The article gives the evaluation of experiments on the bevels of square shaped bars. These bevels were used up to the present time as they resulted from practical experience. The authors show that they can be calculated in advance for a given reduction. These bevels are called "critical" bevels. The results furthermore confirm the theory of average elongation as previously developed by W. Tafel (*Stahl und Eisen*, Vol. 29 (1909) pages 649–663). Bevels have a decreasing influence on the elongation but no influence on the spread. The elongation of bars could be quantitatively calculated in advance by means of "elongation diagrams" in using so-called tension triangles." Elongation tests on a 450 mm. three high mill satisfactorily confirm calculations and practical results. GN(12c)

Tubing from Strip Metal. H. C. PETERSON. *Inco*, Vol. 10, No. 1, pages 13, 19.

Bundy tubing is made from flat strip metal that is rolled into a solid double-wall sweated tube. This construction imparts rigidity, resistance to failure from vibration fatigue, uniform wall thickness and inside and outside surfaces free from scale. MLM(12c)

Further Observations During Plastic Deformation of Electrolytic Copper. (Weitere Beobachtungen bei der Knetbearbeitung von Elektrolytkupfer.) K. BERNHOEFT & W. WUNDER. *Zeitschrift für Metallkunde*, Vol. 22, Jan. 1930, pages 27–29.

Paper presented before the Meeting of the Deutsche Gesellschaft für Metallkunde, Düsseldorf, considers the tearing of electrolytic copper bars during hot rolling. The factors influencing the quality of the bars are mentioned: purity of Cu, surface of the molds, casting temperature and preheating of the molds. Experiments on the rolling quality of various types of Cu are given and stress is laid on the detrimental effect of transverse fractures during rolling which weld together, it is true, but result in a local enrichment in Cu_2O which subsequently may lead to serious failures. EF(12c)

Machining (12g)

Tungsten-Carbide Cutting Materials. F. C. SPENCER. (Western Electric Co.) *Mechanical Engineering*, Vol. 52, Aug. 1930, pages 777–780.

Progress Report No. 2 of Sub-Committee on Tungsten-Carbide Cutting Materials of the A.S.M.E. Special Research Committee on the Cutting of Metals. The report gives a digest of about 50 replies on a questionnaire sent out by the National Machine Tool Builder's Association. The following items are dealt with: extent of application, kind of material cut, machine equipment used, tungsten-carbide tools used, grinding of tungsten-carbide tools, method of tapping, cutting speeds, feeds and depths of cut, economies compared with high-speed steel and Stellite, failures, suggestion for design changes of machinery, attitude of labor with respect to the material. GN(12g)

Present Practice in the Use of Cutting Fluids: Progress Report No. 2 of the Sub-Committee on Cutting Fluids of the A.S.M.E. Special Research Committee on Cutting of Metals. S. A. MCKEE. *Transactions of the American Society of Mechanical Engineers*, Vol. 52, May-Aug. 1930; *Machine-Shop Practice*, pages 103–108.

Includes discussion. Attempts to indicate the trend toward the use of a particular type of cutting agent for a given machining operation on a given kind of metal. Based on information which is presented in tabular form, obtained by questionnaire from 68 large users of cutting fluids. The first table, which is a general summary, lists the number of plants using any of 3 general types of cutting agent (dry, water or emulsions, oils or oil mixtures) and alloy steel, cast-iron brass, Cu and Al. Other tables give more detailed information pertaining to the cutting agents used for the various operations on a given metal. MS(12g)

Machining Seamless Forged Steel Drums for High-Pressure Work. J. D. STRACHAN. *Mechanical Engineering*, Vol. 52, Aug. 1930, pages 751–756.

Paper presented at a meeting of the Philadelphia Section of A.S.M.E., November 26, 1929. Considering the concrete example of machining a Babcock & Wilcox high-pressure boiler drum, all the various operations are followed through. GN(12g)

Test Code for High-Speed Steel for Turning Tools; Report of Sub-Committee "D" on Properties of Materials of the A.S.M.E. Special Research Committee on Cutting of Metals. *Transactions American Society of Mechanical Engineers, Machine-Shop Practice*, Vol. 52, May-Aug. 1930, pages 115–117.

Includes discussion. Tentative code applicable to high-speed tool steel intended for manufacture of lathe and planer tools. Material shall conform to A.S.T.M. standard specification A92–26. MS(12g)

Testing Machineability by Means of the Leyensetter-Pendulum. (Die Prüfung der Zerspanbarkeit mittels des Leyensetter-Pendels.) A. WALLICHS & L. KREKELER. *Archiv für Eisenhüttenwesen*, Vol. 4, July 1930, pages 41–44; *Stahl und Eisen*, Vol. 50, July 31, 1930, page 1096.

The Leyensetter pendulum was constructed to test within a short time the machinability of steels and to replace the expensive and long-time method of taking time-cutting curves. The following tests were made: (1) Testing of the ground cutting tool in the double pendulum to determine if the cutting edge is correct. (2) Testing the tool by a certain turning test. (3) Determination of the wear of the tool by this cutting test by means of the secondary pendulum. The best and most uniform results were obtained with a tool of the composition: C 1.4%, Cr 0.7%, V 0.2%, W 5%. High speed steel cannot be successfully used. The pendulum under certain conditions also appears suitable for testing the cutting qualities of tool steels. GN(12g)

Pickling (12i)

Longer-lived Equipment for Metal Pickling. C. A. CRAWFORD. *Inco*, Vol. 10, No. 1, pages 14, 15, 24.

Reviews many of the recent developments in pickling operations as well as the equipment requirements. MLM(12i)

Cold Working (12j)

The Production of Automobile Sheets. (Die Herstellung von Kraftwagenblechen.) W. KRAMER. *Stahl und Eisen*, Vol. 50, July 10, 1930, pages 991–996; July 17, 1930, pages 1022–1026.

The production methods for automobile sheets are described with special reference to the German cold-rolling method. The arrangement of a mill for cold rolling sheets and additional equipment is considered and the hot and cold rolling process are compared. The physical and chemical properties of automobile sheets including the heat treatment in box-annealing or tunnel furnaces are dealt with. The further development of the cold rolling process (increasing of the production per stand by using stronger rolls and housings), thus allowing a heavier reduction per pass with reduced rolling speed is pointed out. GN(12j)

The Spinning of Aluminum. W. J. LEEDER. *Brass World*, Vol. 26, July 1930, pages 187–190.

"The skilled spinner can produce an almost unlimited variety of shapes, in stock varying from 0.128 down to 0.022", the cost of machines, tools and chucks being small when compared with the expensive equipment which would be necessary to produce a similar range of articles by other methods." Its lightness and strength, combined with its being non-toxic, rustless and incorrodible, and presenting a pleasing bright, silvery surface, makes its appeal irresistible. Its softness, high ductility, ready "flow" under the spinners tools and its brilliant finish, make aluminum an ideal material for the metal spinner. WHB(12j)

Coloring (12m)

The Behavior of Brass and Tombac with Iron Chloride. (Das Verhalten von Messing und Tombak gegenüber Eisenchlorid.) E. BEUTEL & A. KUTZELNIGG. *Korrosion & Metallschutz*, Vol. 6, Jan. 1930, pages 1–3.

The tests reported on were carried out with the following alloys: Tombac: 91.35% Cu, 8.65% Zn; 83.61% Cu, 16.39% Zn. Brass: 69.74% Cu, 30.92% Zn; 65.74% Cu, 34.26% Zn. The test pieces were treated in $FeCl_3$ solutions of various concentrations for various periods of time and the surface films studied in regard to color and composition. The authors arrive at the following conclusions. Yellow and red tombac can be stained gray by iron chloride due to a photochemical reduction of a coating of Cu_2Cl_2 the direct result of the reaction of the attack with $FeCl_3$. Due to oxidation of the moist Cu_2Cl_2 by the atmospheric oxygen, yellow-greenish patina-like films are formed. The behavior of brass varies. Some give a gray color and others are dezincified by $FeCl_3$. The gray surface film can also be secured by other means besides light effects. EF(12m)

A Few Methods for Surface Dezincifying of Brass and Tombac. (Ueber einige Verfahren zur Oberflächenentzinkung von Messing und Tombak.) E. BEUTEL & A. KUTZELNIGG. *Zeitschrift für Metallkunde*, Vol. 21, Dec. 1929, pages 412–413.

The authors critically discuss the known processes of metal coloring based on the reduction of the zinc content on the surface which method approaches the effect of copper plating. Further methods are outlined as follows: (1) Holding brass in a boiling solution or zinc-chloride containing an addition of Cu-chloride in contact with a less noble metal as Zn, Al or Fe. (2) Tombac shows the typical copper color after prolonged boiling in the preliminary pickling bath, containing H_2SO_4 1:10. Dezincing is easily accomplished with Red (91/9) and Yellow Tombac (84/16) in contrast with brass, which gives poor results. (3) The third method consists of applying an Fe-chloride solution (200 g./liter water) for 5 min, cleaning with water and exposing to an open flame to about 120° C. This procedure yields a bright copper layer on the brass due to the reduction of the Cu_2Cl_2. (4) The fourth method prescribes exposing the brass to an iron chloride solution for a certain period of time. The brass assumes a rose-red color. EF(12m)

CHEMICAL ANALYSIS (14)

Rapid Analysis in Foundries. (Schnellanalyse in der Metallgiesserei.) C. TAMA. *Zeitschrift für Metallkunde*, Vol. 21, Oct. 1929, pages 342–343.

This paper reviews the accelerated tests commonly used in foundries for the analysis of various alloys. Stress is laid on the accelerated electrolysis and the utilization of the spectra-colorimetry is discussed in details. EF(14)

The Use of Potassium Titanium Oxalate for the Preparation of a Standard Titanium Solution in Colorimetry. W. M. THORNTON & R. ROSEMAN. *American Journal of Science*, Vol. 20, July 1930, pages 14–16.

Several advantages are claimed for the use of potassium titanium oxalate as an initial substance from which to prepare a standard solution for use in colorimetric work. GN(14)

Rapid Determination of Silicon in Ferro Silicons by Specific Gravity Method. (Dosage rapide de silicium dans le ferro silicium par la methode dite du "poids specific".) E. KAUFMANN. *Journal du Four Electrique*, Vol. 39, June 1930, pages 177–178.

By weighing finely pulverized Fe-Si in water its specific gravity is determined and from the tables the composition of the alloy determined. JDG(14)

Sampling Aluminum Scrap and Waste. ROBERT J. ANDERSON. *American Metal Market*, Vol. 37, July 11, 1930, pages 4, 10.

The importance of securing accurate samples is emphasized and the principles of sampling, the size of sample and its preparation are briefly discussed. Methods recommended for sampling various aluminum- and aluminum-alloy scraps and wastes are also briefly discussed. Usually a combination of grab sampling and fractional selection is best for aluminum and aluminum drosses WHB(14)

Sulphur Determination in Cast Iron Containing Copper. (Zur Schwefelbestimmung in kupferhaltigem Giessereieisen.) ERNEST FISCHER. *Thesis, Technische Hochschule Stuttgart* (1929), 26 pages.

Copper content in all technical irons has a bearing on the accuracy of the sulphur determination according to the commonly used method by Schulte. In all cases, therefore, where the determination of sulphur in copper bearing irons must be absolutely exact, a method must be used avoiding the development of primary hydrogen sulphide. During the course of the examination it was found that such a method is the fusion with sodium peroxide. GN(14)

ECONOMICS (16)

Non-Ferrous Metal Industry of Soviet Russia. V. KARMASHOV. (Technical Bureau, Non-Ferrous Metal Industry). *Engineering & Mining Journal*, Vol. 130, July 24, 1930. pages 67–68.

Swift progress is being made in the industrial development of the U.S.S.R. in the non-ferrous industry. Present annual metal capacities are given for zinc, lead and copper, and for copper rolling and manufacturing plants, and proposed capacities for these metals and for nickel, mercury, and aluminum are indicated. WHB(16)

Consumption of Tin in the United States During 1928. J. B. UMHAU. *Information Circular* 6165, *United States Bureau of Mines*, 1929, 8 pages. See *Metals & Alloys*, Vol. 1, Aug. 1930, pages 654–673. AHE(16)

World's Industrial Cartels. (Les ententes industrielles internationals.) LOUIS MARLIO. *Journal du Four Electrique*, Vol. 39, Apr. 1930, pages 125–128.

A review of the industrial cartels of the world principally connected with chemical and metallurgical industries. JDG(16)

Gold-Silver, Copper and Lead in Texas in 1928. CHAS. W. HENDERSON. *Mineral Resources of the United States*, 1928, part 1, May 28, 1930, *United States Bureau of Mines*, pages 559–561.

The gold, silver, copper and lead production of Texas in 1928 was valued at $899,204, as contrasted with $628,515 in 1927. Gold increased from $8192 to $10,115, silver from 1,034,0866 to 1,340,622 ounces, copper from 21,458 to 447,792 pounds and lead from 487,984 to 695,570 pounds. AHE(16)

Gold, Silver and Copper in Wyoming in 1928. CHAS. W. HENDERSON. *Mineral Resources of the United States*, 1928, part 1, April 15, 1930, *United States Bureau of Mines*, pages 437–439.

In 1928, Wyoming metal mines produced $1083 worth of gold, silver and copper, a decrease of $120 from 1927 Gold production was halved, silver increased 10 times, and copper increased from nothing to 2604 pounds ($375). AHE(16)

Some Notes on French Electrochemical and Electrometallurgical Industries. (Considerations sur les industries electrochimiques et electrometallurgiques francaises.) P. BUNET. *Journal du Four Electrique*, Vol. 39, Mar. 1930, pages 85–93.

A survey of the distribution of 800 million kwh. of energy annually produced in France. 15% of it is used for electrochemical and electrometallurgical purposes. The uses in the above field are summarized. JDG(16)

Steel Works in Italy. (Impianti Siderurgi Esistenti in Italia.) *La Metallurgia Italiana*, Vol. 8, June 1930, p. 681–689.

The report of Dec. 31, 1929, made by the Facist National Association of all Italian Steel Works, shows that there are in Italy: 5 blast furnace companies with 2 electric shaft furnaces, 14 coke blast furnaces and 5 charcoal blast furnaces; Eleven electric furnace companies for cast iron and ferro-alloys, with 79 electric furnaces; 38 steel companies and foundries, with Bessemers, 133 open-hearth furnaces and 89 electric furnaces; 49 steel works having rolling mills; 83 companies for making wire. GTM(16)

Italian Aluminum Industry. (Industrie italienne de l'aluminium.) *Journal du Four Electrique*, Vol. 30, June 1930, pages 205–207.

Italian Al industry is aided by abundant bauxite deposits and leucite mines. Development to the present state is described. Statistics given. JDG(16)

Summarized Data of Silver Production. CHARLES WHITE MERRILL. *Economic Paper* 8, *United States Bureau of Mines*, 1930, 58 pages.

World production of silver from 1493 to 1927 has been over 14 billion ounces, ½ of which has been produced in the last 39 years. Mexico has supplied 35.68% of this output, United States 20.87, Bolivia 10.92, Peru 9.40, Canada 3.76, Germany 3.46, Australia 3.19, Austria 2.26, Chile 2.05, Japan 1.69, Spain 1.40 and all others 5.32%. Production figures by countries for 1493 to 1600, 1601 to 1700, 1701 to 1800, by decades to 1850, 5 years periods to 1875 and annually since 1876 are given in a large folded table. AHE (16)

The Iron and Steel Industry on the Continent. *Engineer*, Vol. 150, July 4, 1930, pages 17–18.

The Economic Advisory Council sent a delegation to the Continent to study the industrial conditions in the iron and steel districts in France, Belgium, Luxembourg, Germany and Czechoslovakia. This article is a summary of the Report prepared by the National Federation of Iron and Steel Manufacturers. Production, exports, wage scales, trade unions, etc. are discussed for each of the five countries visited. An editorial commenting on this same report appears in *Engineering*, Vol. 130, July 4, 1930, pages 17–18. LFM(16)

Engineering Markets of the World. A. J. LIVERSEDGE. *Engineering*, Vol. 130, Part I, July 18, 1930, pages 84–87; Part III, Aug. 8, 1930, pages 160–162.

Considers the following engineering products: iron and steel and manufactures thereof, machinery, electrical apparatus and vehicles. Gives graphs and figures of imports of these products into the United Kingdom. Comparison is made between the American and the British markets. India is England's best market for engineering materials which include iron and steel and manufactures thereof, machinery, electrical apparatus and motor vehicles. India places a duty on some of these commodities particularly most forms of iron and steel. Tables are given showing export and import figures. India is making an attempt to increase her home production of iron and steel so figures show a decline in imports from the United Kingdom. Since 1913 there has been a decline of 16% in value of non-ferrous metals imported by India from the United Kingdom. In iron and steel Belgium is Britain's chief competitor in the Indian trade. LFM(16)

Italian Ferro Alloys Industry in 1929. (L'Industrie italienne des ferro alliages en 1929.) *Journal du Four Electrique*, Vol. 39, Apr. 1930, pages 131–132.

A brief statistical description of Italian ferro alloy industry. JDG(16)

Production of Electrolytic Zinc. (Le production de zinc electrolytique.) *Journal du Four Electrique*, Vol. 39, Apr. 1930, page 129.

A brief summary of the production of electrolytic zinc in different countries in 1929. JDG(16)

Rail Rates on Iron and Steel. E. T. Good. *Engineer*, Vol. 150, July 4, 1930, page 7.

Quotes figures to show that transport costs for iron and steel in Britain are lower than in U. S. or on the Continent. British ton-mile rates are high due to the short hauls but the total charges are low. LFM(16)

Lead in 1928. Elmer W. Pehrson. *Mineral Resources of the United States*, 1928, part I, July 2, 1930. *United States Bureau of Mines*, pages 607–643. 6 references.

The production of primary refined lead in 1928 was 781,071 short tons, 2% less than 1927. This included a 6% decrease in metal from domestic ores and 21% increase from foreign material. The recovery of secondary lead in pig and alloys broke all previous records, amounting to 308,600 tons, 49% of the primary lead from domestic ores. Recovery as pig lead amounted to 45% of the total secondary material. The total consumption of lead in the United States in 1928 amounted to 930,500 tons, an increas e of 11% over 1927. The chief use was in storage batteries, this source using 26% more lead than in 1927. Cable covering was second and had a 12% increase. White lead was third in importance, but decreased from 1927 in amount consumed. Mine production of lead in the United States decreased 6%. World smelter production of lead in 1928 amounted to 1,879,000 tons, a decrease of about 1%. Of this the United States produced 35%, Mexico 13%, Australia 9% and Canada 8%. AHE(16)

Gold, Silver, Copper, Lead and Zinc in Nevada in 1928. V. C. Heikes. *Mineral Resources of the United States*, 1928, part 1, May 7, 1930, *United States Bureau of Mines*, pages 441–478. 6 references.

In 1928, the total value of mine production of gold, silver, copper, lead and zinc in Nevada was $31,033,776, 33% more than in 1927. The quantity and value of each metal except lead increased, gold from 150,346.16 to 175,157.79 ounces, silver from 5,379,179 to 5,481,574 ounces, copper from 120,259,276 to 158,876, 883 pounds and zinc from 6,344,523 to 6,796,713 pounds. Lead decreased from 15,784,818 to 15,747,444 pounds. AHE(16)

Gold, Silver and Lead in South Dakota in 1928. Chas. W. Henderson. *Mineral Resources of the United States*, 1928, part 1, April 15, 1930, *United States Bureau of Mines*, pages 429–435. 7 references.

From 9 mines, South Dakota in 1928 produced $6,618,067 worth of gold, silver and lead, a slight decrease from 1927. Lead production was 74,000 pounds, valued at $4292, about half of the production in 1927, while silver output was 90,547 ounces, valued at $52,970, a slight decrease. The balance was gold. Most of this came from the Homestake gold mine, at Lead, the largest gold mine in the United States, which has been producing almost continuously since 1875. AHE(16)

Gold, Silver, Copper, Lead and Zinc in New Mexico in 1928. Chas. W. Henderson. *Mineral Resources of the United States*, 1928, part 1, May 28, 1930, *United States Bureau of Mines*, pages 529–557. 18 references.

The value of gold, silver, copper, lead and zinc produced in New Mexico in 1928 amounted to $18,815,863, an increase of 20%. Gold production increased from 29,241.87 to 32,912.41 ounces, silver decreased from 890,083 to 827,793 ounces, copper increased from 74,251,863 to 89,854,646 pounds, lead decreased from 16,052,855 to 15,610,501 pounds and zinc increased from 59,603,000 to 62,406,000 pounds. The gold production came from copper ore (50%), lead-zinc ore (45.7%), dry and siliceous ore (3.3%) and placers (1%). Silver was produced from lead-zinc ore (66.8 %), copper (23.8%), lead ore (6.2%) and dry and siliceous ore (3.2%). AHE(16)

PLANTS & LABORATORIES (17)

A Model Die Casting Plant in the New York District. A. F. Waltz. *Brass World*, Vol. 26, Aug. 1930, pages 203–207.

An illustrated description of the plant of the Allied Die-Casting Corp. at Long Island City, N. Y. WHB(17)

Producing Valves in a Modern Plant. D. A. Clark. *Modern Machine Shop*, Vol. 2, July 1930, pages 11–16.

Describes the equipment in a typical plant. MLM(17)

The Tube Mill of the Rheinischen Metallwaren-und Maschinenfabrik at Düsseldorf. (Das Rohrwerk der Rheinischen Metallwaren-und Maschinenfabrik in Düsseldorf.) A. Stick. *Stahl und Eisen*, Vol. 50, June 26, 1930, pages 905–909.

The plant is described where Ehrhardt originated his press and draw process for manufacturing seamless tubes, including a description of machinery, furnaces, etc. GN(17)

The New Plant of the Mannesmann Tube Works, Division Schulz Knaudt at Huckingen. II. Thomas Steel Work Plant. (Die Neuanlagen der Mannesmannröhren-Werke, Abteilung Schulz Knaudt, in Huckingen. II. Thomasstahlwerk.) J. Postinett. *Stahl und Eisen*, Vol. 50, June 12, 1930, pages 825–834; *Iron & Coal Trades Review*, Vol. 121, Aug. 29, 1930, pages 292–293.

Report No. 187 of the Steel Mill Committee of the Verein deutscher Eisenhüttenleute. A detailed and illustrated description is given of the newest German Thomas steel plant which includes some interesting improvements. The dimensions and the operating of the whole equipment are given, thus permitting one to draw conclusions as to the possible efficiency of the new mill. GN+RHP(17)

Revamped Forging and Plating. Fred L. Prentiss. *Iron Age*, Vol. 125, April 24, 1930, pages 1217–1220, 1266.

Describes the automobile bumper plant of Eaton Axle and Spring Co., Cleveland. Outstanding features of the plant are: cleaning electrically in acid solution, semi-automatic operations and automatic polishing and plating. Bumpers are made of high C steel having 0.80 to 0.95% C. Cr plating is applied to a thickness of 0.0006 in. Combined coating of Ni, Cu and Cr is 0.0096 in. thick. Cr must cover nickeled surface. Plant efficiency increased by changes in forging practice. Continuous conveyor-type furnaces used. VSP(17)

Metallurgical Laboratory of the Timken-Detroit Axle Co. Combines Scientific Research and Production Control. J. Geschelin. *Automotive Industries*, Vol. 62, April 5, 1930, pages 546–548.

The article gives a description of the research activities of the Timken-Detroit Axle Company. The research equipment is described. GN(17)

Tube Mill of Flexible Design. *Iron Age*, Vol. 125, April 24, 1930, pages 1226–1227, 1265.

Describes new tube mill of Laclede Steel Co., Alton, Ill., having an annual capacity of 45,000 tons of butt-welded pipe. Both standard and extra-heavy pipe of either Bessemer or open-hearth steel is made. Furnaces fired by natural gas. Skelp furnace is of regenerative type, with narrower chambers than usual, and deeper hearth. Beneficial effect of this design is low exhaust gas temperature and quick-acting furnace. Rehandling of pipe avoided. Other units are: Three 80 ton and one 100 ton open-hearth furnaces; a 32 in. bloomer, 18 in. billet and bar mill; a 10 in. four-high continuous hot strip mill; and one 8 in. cross-country mill. VSP(17)

MACHINERY & SUPPLIES (18)

The Care and Maintenance of an Engineering Works. L. Blackburn. (Brown of Huddersfield.) *Foundry Trade Journal*, Vol. 42, Mar. 6, 1930, pages 175–178.

Includes discussion. Paper read before West Riding of Yorkshire branch of Institute of British Foundrymen. Deals with the difficulties and problems which face everybody in an executive position. Branches of engineering that are dealt with are classified as follows: (1) Power, relating chiefly to line shafting, countershafts and prime mover. (2) Machine tools, including lathes, planing machines, milling, slotting and grinding machines, also capstan, automatic and special-purpose machine tools. (3) Overhead travelling cranes and all class of lifting equipment. (4) Foundry and blacksmith's machine equipment. VSP(18)

Rolling Mills for Iron Steel, Metals and Alloys. (Walzwerke für Eisen, Stahl, Metalle und Legierungen.) J. Schmitz. *Krupp'sche Monatshefte*, Vol. 11, June 1930, pages 142–147.

Rolling mill equipment, as built by the Krupp-Gruson Works for a great variety of purposes is described and illustrated in the article. The line of equipment covers hot as well as cold roll mills. GN(18)

Metal Presses. (Metallpressen.) J. Schmitz. *Krupp'sche Monatshafte*, Vol. 11, June 1930, page 148.

The article covers metal presses for producing tubes, bars, fine wires and shaped profiles. GN(18)

Machines for the Fabrication of Cables and Wire Ropes. (Maschinen für Kabel-und Drahtseilfabriken.) P. Wieghardt. *Krupp'sche Monatshefte*, Vol. 11, June 1930.

Among the machines described a new 8-spool tangential paper spinning machine for cables, a 48 spool rope spinning machine and the lead presses are especially of interest. GN(18)

MISCELLANEOUS (20)

Kuznetzoff-Zhukovsky Method for Preparation of Alumina in Electric Furnaces. (Procede Kuznetzoff-Zhukovsky pour la fabrication de l'alumine au four electrique. *Journal du Four Electrique*, Vol. 39, May 1930, page 180.

With high Si bauxites the ore is melted with iron turnings, coal and $BaCO_3$. FeSi formed and separated. JDG(20)

Metallurgical Operations at Mount Lyell, Tasmania. R. M. Murray. *Engineering & Mining Journal*, Vol. 130, July 10, 1930, pages 12–15.

This section, originally regarded as a gold mining property, is now recognized as an immense copper deposit. Flow sheets are given for the Mt. Lyell all-flotation concentration plant and for the sintering, blast furnace and refining operations. The total weekly output of the electrolytic plant is 168 tons of cathode copper, 2.3 tons of anode slime and 3 tons of first grade bluestone. WHB(20)

Power Economy in German Steel Mills. (Die Kraftwirtschaft auf deutschen Eisenhütten.) *Stahl und Eisen*, Vol. 50, June 19, 1930, pages 857–88.

Report No. 140 of the Committee of Heat Economy of the Verein deutscher Eisenhüttenleute. The power and heat economy of German steel plants is presented in detail by diagrams. The efficiency of gas engines and steam turbines is considered. Modern steam boilers for different types of fuels are dealt with. The total steam balance for the production of electric current by using high pressure steam and the distribution of energy are described for a certain steel mill. Examples are given for measuring and supervising the distribution of energy in steel plants. GN(20)

On the Heat Content of Slags. (Ueber den Wärmeinhalt von Schlacken.) G. Naeser. *Mitteilungen Kaiser Wilhelm Institut für Eisenforschung*, Vol. 12, 1930, *Report* 143, pages 7–12; *Stahl und Eisen*, Vol. 50, April 14, 1930, page 554.

The author determined the specific heat of open-hearth slags from 300° C. up to the melting point. Even large variations in chemical composition have practically no bearing on the heat content. GN(20)

Principal Requirements in the Latest Testing Society Specifications for Ferrous Castings. *Research Group News*, Vol. 7, July 1930, pages 308–314.

Outlines in convenient, condensed form the major requirements of A.S.T.M. specifications as they will be, following formal approval by the society. Specification given for steel, malleable iron and gray-iron castings. MLM(20)

Amalgams. (Die Amalgamfrage.) Fenchel. *Zeitschrift für angewandte Chemie*, Vol. 41, Oct. 27, 1928, pages 1182–1184.

There is no conclusive evidence of danger due to silver amalgams used in filling teeth. (20)

LABORATORY APPARATUS (21)

A New High Temperature Furnace on the Principle of Surface Combustion. (Ein neuer Hochtemperaturofen nach dem Princip der Oberflächenverbrennung.) Eugen Ryschkewitsch. *Chemische Fabrik*, Vol. 8 Feb. 19, 1930, pages 61–63.

A new high temperature gas furnace for laboratory use has been developed making use of the contact of the gases with hot surfaces to increase the temperature obtained. New features are that the gas and air are not mixed before entering the furnace and lowering the resistance to gas flow. The construction should be symmetrical and have good heat insulation. It consists of 2 concentric cylinders of highly refractory material, MgO or ZrO_2, the space between them being the combustion chamber. In the combustion chamber rods or tubes of refractory material are placed vertically to increase the surface contact and decrease the volume without materially increasing the resistance to the flow of gas. The burnt gases pass around the outside of the cylinders and then around the air inlet, thus utilizing their heat to preheat the air. The units are easily replaceable. The combustion is very rapid, the gases remaining in the combustion only $^1/_{100}$ second. With ordinary city gas 2100° C. can be obtained and with producer gas 1900° C. A small furnace of 200 cc. capacity can be heated to 1600–1700° in 5 minutes. The furnace is useful for firing ceramics such as ZrO_2, MgO and Al_2O_3 in an oxidizing or neutral atmosphere and for melting and alloying platinum and similar metals. The theory is that the large hot surface in contact with the gas acts as a catalyst. CEM(21)

Laboratory Furnaces for High Temperatures. (Laboratoriumsöfen für hohe Temperaturen.) F. Kanz. *Stahl und Eisen*, Vol. 50, July 31, 1930, pages 1094–1095.

F. Kanz reviews recent publications which deal with the construction of laboratory furnaces for high temperatures. The publications by Le Rossignol & W. Fehse (*Giesserei Zeitung*, Vol. 24 (1927), pages 441–446) and that by W. Cohn (*Giesserei*, Vol. 15 (1928) pages 1289–1292) describe electric resistance furnaces with tungsten wire winding as resistance. The author furthermore briefly describes and illustrates a furnace heated with compressed gas and air built by H. Salmang & H. Bros. (*Berichte Deutsche Keramische Gesellschaft*, Vol. 10 (1929), pages 429–445). In this paper Krupp's radiation furnace and H. von Wartenberg's zircon dioxide furnace (*Zeitschrift für anorganische und allgemeine Chemie*, Vol. 176 (1928), page 360) which can be used for temperatures up to 2600° C., is also considered. Another electric resistance furnace, using granulated carbon (Kryptol) as resistance, was developed by the Deutsche Gasglühlicht-Auer Gesellschaft. Temperatures up to 2000° C. can be attained in this furnace. GN(21)

FOUNDRY PRACTICE & APPLIANCES (22)

Progress in Foundry Practice in 1928 and 1929. (Fortschritte im Giessereiwesen in den Jahren 1928 and 1929.) H. JUNNGBLUTH. *Stahl und Eisen*, Vol. 50, July 31, 1930, pages 1091–1094; Aug. 7, 1930, pages 1135–1138; August 14, 1930, pages 1169–1172; August 21, 1930, pages 1202–1204, 159 references.

The article summarizes the progress in foundry practice of the last 2 years all over the world in 3 groups: (1) Constitution and properties of cast iron, (2) melting practice (3) molding and cleaning of castings. GN(22)

Effect of Section Size on Physical Properties of Cast-Iron. A. L. BOEGEHOLD. *Engineering*, Vol. 130, Aug. 29, 1930, page 281.

Abstract of paper read before the American Society for Testing Materials, June 1930. See *Metals & Alloys*, Aug. 1930, page 683. LM(22)

High-Test Cast Iron. J. W. BOLTON, Chairman, Sub-Committee XIII of A. S. T. M. Committee A-3 on Cast Iron. *Appendix to Report of Committee A-3, Preprint* 11, June 1930 Meeting, *American Society for Testing Materials*, 3 pages.

Brief statement as to production of low carbon high strength irons. These may be prepared by using a charge, as steel, in the cupola, which is low enough in carbon to offset the carbon pick-up; by using a charge of approximately the desired composition and burning out some of the carbon, as in the air furnace; or by burning out or diluting the carbon. In any case, around 2.75–3% total carbon is aimed for. To produce this 60–95% steel charges are often used in the cupola. A 48″ bed of coke is used above the tuyères, burned through and fresh coke added to regain that level before charging stock. The metal to coke ratio is about 6 or 7 to 1. Charge early, let soak one or two hours, with taphole and one peephole open. Use 30,000–37,000 cu. ft. air per ton. Fast melting and hot iron are desirable. A shallow well and frequent taps favor low carbon. In charging the air furnace pieces should be placed so as to expose the greatest surface to the heat. In dilution processes steel scrap is melted in Bessemer, open-hearth or electric furnaces and suitable additions made, in the furnace or ladle, of cupola-melted cast iron, the proportions being chosen to give the desired analysis. HWG(22)

Electric Gray Iron Entirely from Scrap. N. L. TURNER. *Electrical World*, Vol. 96, July 12, 1930, pages 68–69.

A three-ton electric melting furnace is being successfully operated at the plant of the Beach Foundry, Ltd. of Ottawa, Canada, using all scrap metal. The products manufactured are coal and wood stoves, furnaces, gas and electric ranges. The continuous operation results in increased production, lower costs of iron at the spout, and greater flexibility with increased speed in coping with rush orders. WHB(22)

Notes on Castings. L. SHANE. *Journal American Society of Naval Engineers*, Vol. 41, Nov. 1929, pages 589–596.

Difficulty in making composition castings is overcome by discontinuing the use of open-flame furnaces, such as Schwartz, Rockwell or Monarch furnaces and returning to practices of 35 years ago. Gives method of manufacture of manganese bronze. (22)

A Review of Modern Cupola Practice. H. W. KEEBLE. *Foundry Trade Journal*, Vol. 42, Mar. 13, 1930, pages 199–201.

Paper read before London Junior Section of the Institute of British Foundrymen. Deals with principles of design for general practice and with practical cupola operation. A high cupola from hearth to charging door melts more Fe in a given time with less fuel than a low one of same internal diameter. Lining is built of firebricks and should be 4–5 in. thick for small cupolas, and 6–9 in. thick for large ones. Tuyères should be rectangular, flared out at internal end and regularly spaced around cupola. Air ratio requirements should be calculated on the coke to Fe ratio. Examination of conditions of interior of cupola and constituents of the drop after a previous blow will supply much information as to whether cupola is operating efficiently and economically. Patched lining must be resistant to abrasion and chemical action of heat and slag, and daubing should just replace lining worn and burnt away each day. Construction of a tap hole is decided by the arrangement of the cupola. Bed coke should be hard and dense, and possess a metallic luster. It will consist of 90% C and not more than 1% S and remainder ash and moisture. In charging, stock should be introduced in same order each time usual flux is limestone. VSP(22)

The Casting of Ship Propellers. *Foundry Trade Journal*, Vol. 42, Mar. 20, 1930, page 220.

Extracted from *Giessereipraxis*. Propellers are cast in steel, iron and bronze. Shrinkage of metal is important in successful manufacture. With iron or bronze the same compositions and same casting temperatures should be used to have same shrinkage. Cast iron propeller should be kept within the following limits: C 2.6 to 2.8; Si 1.7 to 1.8; Mn 0.8 to 0.9; S 0.08 to 0.1; and P 0.3 to 0.5%. Bronze propeller should have a strength of 32 tons and 25 to 30% elongation. Another suitable alloy has a composition of: Mn 1; Fe 1; Ni 2; Cu 57; Zn 38.5 and Al 0.5%. Gives methods of casting. VSP(22)

Modern German Methods of Manufacturing Baths and Other Sanitary Ware. *Foundry Trade Journal*, Vol. 42, Mar. 20, 1930, pages 210–213; Mar. 27, 1930, pages 231–233.

Gives details of methods employed in Germany. Discusses hand molding, pattern plate method, molding machine method, bath foundry lay-out and flushing tanks. Takes up also the manufacture of wash basins, sinks, flushing cisterns, etc. VSP(22)

American Brass Foundry Practice. Part VI. Gating the Casting. CHARLES VICKERS. *Foundry*, Vol. 58, Mar. 15, 1930, page 88–90.

Describes principles and methods of gating, casting pump bodies vertically and arrangement for horizontal casting. VSP(22)

Increasing Foundry Production with Existing Box Plant. J. DESCHAMPS. (Kryn & Lahy Ltd., Letchworth). *Foundry Trade Journal*, Vol. 42, Mar. 13, 1930, page 198.

A process invented by Labois for molding of castings in any metal, intended to be used more particularly in pattern plate molding. Permits the making in one flask of twice as many molds from the patterns mounted on a pattern plate, and consequently allows the halving of the number of reserve flasks. Can be used for molding of all castings which may be obtained by use of pattern plates and cores. VSP(22)

Oxidation Losses in Melting Steel Scrap in Small Cupola. (Zu- und Abbrandverhaltnisse beim Einschmelzen von Stahlschrott im kleinen Kupolofen.) H. NIPPER. *Stahl und Eisen*, Vol. 50, July 10, 1930, pages 999–1000.

A paper by E. Piwowarsky, H. Langebeck & H. Nipper in *Giesserei*, 1930, Vol. 17, pages 225–230, 275–280, 352–360 is summarized. (1) The carbon content of the melt decreases with increasing amount of scrap, but the percentage carburization and the tendency to pick up sulphur increase. The loss of manganese and silicon increases too. (2) The influence of varying air blast is practically unimportant. Forced melting decreases sulphurization. (3) Increasing coke weight in charge increases melting zone and temperature, and therefore carburization and sulphurization. (4) Melting with increased slag quantities has no influence on carburization but an increased sulphurization. Loss of silicon and manganese increases. (5) Only liquid metal carburizes in the cupola. GN(22)

Problems Met in Pattern-Plate Moulding. A. IRVINE. *Foundry Trade Journal*, Vol. 42, April 3, 1930, page 248.

A paper read before Falkirk section of the Institute of British Foundrymen. Discusses difficulties encountered in making pattern plates such as bending, twisting, springing and drawing or sinking. VSP(22)

Some Aspects of Jobbing Moulding. S. SOUTHCOTT. (Taylor & Sons, Ltd.) *Foundry Trade Journal*, Vol. 42, Feb. 20, 1930, pages 135–138, 148.

Includes discussion. Paper before Wales and Monmouth branch of Institute of British Foundrymen. A jobbing shop produces anything in metal from a safety razor to a high pressure cylinder. Bad gating is one of the chief causes of half the foundry troubles. Cylinder castings should be cast on end. Small round pencil gates should be used for this class of work. Where feeding is necessary it should be done at the highest possible point and as far from machining parts as practicable. Describes the molding of a 28 in. cylinder with steam chest combined. Gives a number of illustrations. VSP(22)

Hot Iron Obtained by Economical Cupola Operation. H. V. CRAWFORD. *Foundry*, Vol. 58, April 1, 1930, pages 116–118.

Best results obtained in cupola melting depends on: starting with right bed; maintaining right bed; starting with right amount of air and maintaining right amount of air. Following table gives amount of air in lbs. recommended for different iron to coke ratios.

Ratio	Lbs./minute
12 to 1	25.3
11 to 1	26.0
10 to 1	26.8
9 to 1	27.8
8 to 1	29.0
7 to 1	30.6

Coke to be used is about 88% C. Construction of tuyères should be such that air is distributed evenly around cupola. Flame should be eliminated at charging door. Coke charges are to be uniform in volume from start to finish and should be level in each charge. Iron charges should be level in each charge and weight to vary depending on inside lining diameter. Ordinary limestone is satisfactory for flux charges. Under good operating conditions maximum tonnage rating of cupolas can be obtained and under best operating conditions it can be exceeded. VSP(22)

Pressure Die-Cast Aluminium Alloy Test-Pieces. J. D. GROGAN. (National Physical Laboratory.) *Institute of Metals, Advance Copy* No. 530 (1930) 18 pages.

The attack of a molten aluminum alloy containing 8% copper on alloys suitable for use in vessels to hold the molten alloy was determined by immersing rods in the molten alloy and determining the amount of metal dissolved. Nickel-chromium (80–20) was attacked very rapidly by the molten aluminum alloy. Of the 6 materials investigated cast iron was the least attacked. A chromium-vanadium steel was only slightly inferior to cast iron and was used in the preparation of the die cast samples. Laboratory equipment was constructed for casting the test specimens. The molten alloy was held in a U-shaped tube and forced into the cast iron die both by gravity and by air pressure from an 80-lb. line. Cylindrical specimens 1″ × 3″ were cast to determine the flow of metal in the mold. It was found that irrespective of the position of the gate or direction of the mold a shell was first formed, which often was not completely filled. All samples were unsound in various degrees. Small round tensile test specimens were cast from an 8% copper alloy, a "Y" alloy, a 4% Cu—3% Si alloy and a 12% silicon alloy. Many of the samples were contaminated with "dirt", probably Al_2O_3. No satisfactory castings were obtained from the 8% copper alloy. The best mechanical properties were obtained with the 4% copper–3% silicon alloy and the "Y" alloy, the results for the former being the more consistent. Neither casting nor mold temperature appeared to have much effect on the properties of the specimens. The copper-silicon alloy had a tensile strength of about 30,000 lbs./in.^{2} with an elongation of about 4%. JLG(22)

FURNACES & FUELS (23)

Electric Furnaces with Controllable Atmospheres. C. L. HEISLER, JR. (General Electric Co.). *Industrial Engineering*, Vol. 88, May 1930, page 229–231.

The article deals with design and operation of electrical furnaces for different purposes. GN(23)

The Schury Furnace. (Der Schury-Ofen.) FRIEDRICH BROCKE. *Giesserei Zeitung*, April 1, 1930, pages 195–197.

Discusses first the most important steel melting furnaces and steel production processes with regard to their advantages and disadvantages. The Schury furnace, which is of the open hearth type with regenerative firing and which uses tar or heavy oil as a fuel, and the results of its use are compared with those of the Siemens-Martin (open hearth) furnace, by means of heat balances. These indicate that the Schury furnace is the more efficient despite the fact that it was started from the cold condition, whereas the open hearth furnace was already at operating temperature. This property enables it to lend itself to flexible production schedules, since the standby losses are reduced. In spite of the fact that it operates at a higher temperature, the life of the linings is about the same as for the open hearth furnace. Last, but not least, the Schury furnace produces a higher quality of steel which compares favorably with electric furnace steel. AJM(23)

The Utilization of Waste Heat in the Steel Industry. C. W. E. CLARKE *Preprint*, May 1930 Meeting, *American Iron & Steel Institute; Engineering*, Vol. 129, June 6, 1930, pages 749–750; *Iron & Coal Trades Review*, Vol. 120, June 27, 1930, pages 1021–1022; *Blast Furnace & Steel Plant*, Vol. 18, July 1930, pages 1164–1166.

General discussion. Advocates running steam plant with blast furnace gas plus pulverized coal when the supply of blast furnace gas is insufficient. With proper lay-out and operation, practically the only purchased fuel need be in the coke oven plant. HWG+LM(23)

Progress in the Construction of Low Frequency Electric Furnaces. (Les Progres Realises dans la construction des Fours á induction á basse frequence.) DR. F. WALTER. *Journal du Four Electrique*, Vol. 39, June 1930, pages 213–219; *Siemens Zeitschrift*, Vol. 10, April-May 1930, pages 254–260.

Describes the construction of Siemens low frequency induction furnace. This furnace can be used for melting brass, bronze, nickel alloys. Power used per ton of charge is 180–200 kw. GTM(23)

A User's Viewpoint on the Electric Furnace. FREDERICK A. MELMOTH. *Electrical World*, Vol. 96, July 19, 1930, pages 128–30.

An appreciation of the virtues and the value of the electric furnace in the steel casting foundry from the eyes of the furnace operator. Performance characteristics are indicated for a 1½-ton Pittsburgh Electric Furnace Corp. furnace which was used for both plain carbon and alloy steels for small castings. WHB(23)

The Influence of Age on Melting Time and Energy Consumption of Electric Steel Furnaces. (Der Einfluss des Ofenalters auf die Schmelzungsdauer und den Energieverbrauch von Elektrostahlöfen.) S. KRIZ & H. KRAL. *Stahl und Eisen*, Vol. 50, Feb. 20, 1930, pages 221–222.

Report No. 181 of the Steel Mill Committee of the Verein deutscher Eisenhüttenleute. Includes discussion. Investigations were made on a 5.5 ton Nathusius arc furnace to determine how melting time and consumption of energy change from one relining of the arch of the furnace to the next one. GN(23)

Melts Steel in Electric Furnace. R. N. BLAKESLEE. *Foundry*, Vol. 58, April 1, 1930, pages 118–119.

Describes high frequency coreless induction furnaces installed at Beaver Falls plant of Babcock & Wilcox Tube Co. by the Ajax Electrothermic Corp., Trenton, N. J. Metals melted are heat, chemical and abrasion resisting type. Temperature required is between 2900 and 3200° F. Daily average production is 4000 lbs. VSP(23)

Gas Modernizes the Forge Furnace. J. B. NEALEY. *American Gas Association Monthly*, Vol. 11, Dec. 1929, pages 727–730.

Study of conditions affecting burning of steel and underlying causes of this behavior. Effect of oxidizing and reducing atmospheres on steels heated for forging. (23)

Metal Recuperators of Krupp High Heat Resisting Steel for Gas and Air on a Pusher Furnace. (Metallvorwärmer aus Krupp'schen hochhitzebeständigen Stahl für Luft und Gas an einem Stossofen.) H. BANSEN. *Stahl und Eisen*, Vol. 50, June 19, 1930, pages 884–885.

The practical results in using Krupp's alloy Nichrotherm as a construction material for metal recuperators are reviewed. This alloy gave excellent results for the purpose mentioned. Metal recuperators offer many advantages, such as low cost of installment, short heating time and an easy and uniform regulation of temperature. GN(23)

High-Frequency and Arc Electric Furnaces Compared. H. NEUHAUSS. *Iron Age*, Vol. 125, April 17, 1930, page 1180.

Abstract translation of article in *Stahl und Eisen*, Vol. 49, page 689. High frequency furnace of 90, 145, 240 and 500 lb. capacity respectively consume 1270, 1050, 770 and 725 Kw. hr./ton of steel: Arc furnaces of 4, 6 and 8 ton capacities require 670, 550 and about 480 Kw. hr. to the ton. Considers the advantages and applications of high-frequency furnaces. See *Metals & Alloys*, Aug. 1929, page 79. VSP(23)

Heating with Pressure Gas. (Pressgasbeheizung.) F. CLEMEN. *Stahl und Eisen*, Vol. 50, June 19, 1930, page 881–882.

The article considers by certain examples the possibilities which result for steel mills in using gas under pressure. The advantage of using pressure gas without preheating is especially emphasized. GN(23)

Jewellers' Furnaces. R. GALLAND. *Electrical Review*, Vol. 106, April 11, 1930, page 672.

Describes some conditions in which small electric resistance furnaces for melting and annealing have proved to be economical. MS(23)

Actual Tendencies in the Construction and Use of Electric Foundry Furnaces. (Les tendences actuelles dans le construction et l'emploi des fours electriques de fonderie.) *Journal du four Electrique*, Vol. 39, Mar. 1930, pages 94–95.

A discussion of paper by Albert Levasseur given in *Journal du Four Electric* in May 1929, abstracted in *Metals & Alloys*, Aug. 1930, page 684. JDG(23)

Modern Induction Furnaces. (Ueber neuzeitliche Induktionsöfen.) N. BROGLIO. *Stahl und Eisen*, Vol. 50, June 19, 1930, pages 885–888.

N. Broglio reviews a paper in *Engineer*, 1929, Vol. 148, pages 652–654 and 680–682 which deals comprehensively with the present state of induction furnaces in England. GN(23)

Rotary Cylindrical Furnace for Melting Foundry Iron. (Le four cylindrique tournant pour la fusion des fontes de moulage.) AUGUSTE LE THOMAS. *Revue de Metallurgie*, Vol. 27, May 1930, pages 256–264, 8 references.

A cupola is satisfactory for usual irons but difficult to operate with low carbon or high melting irons. A 5-ton furnace is described. Horizontal steel shell is lined with 520 mm. silica bricks which lasts 120–150 heats. It rotates making one revolution in 80 seconds. Fired with pulverized coal. The axial opening is used for gas escape and charging. The tapping hole is in the middle. Separation of combustion phenomena from melting is very important. Flame control is perfect. The bath can be kept indefinitely. Metal losses are about 1% instead of average cupola losses of 4–5%. With an average coal and without air preheating 1600-1650° C. can be attained easily. Grain is refined and pearlite less open. In a 4.5 ton furnace the melting of 2.5% C and 0.8–1.0 Si iron to be cast at 1600–1650° averaged 16–18% coal, taking about 3 hours 45 minutes per melt. JDG(23)

Modern Industrial Furnaces. JOHN FALLON. *Metal Industry* (London), Vol. 36, Feb. 7, 1930, pages 165–167; Feb. 14, 1930, pages 189–192; Feb. 21, 1930, pages 213–214.

Condensed paper read before the Co-ordinating Committee, Jan. 16, 1930. Considers early development of furnaces and the first patents granted in England. Main functions of furnaces may be classified as follows: (1) Gasification of fuels; (2) Complete oxidation of fuels and conversion of latent heat into utilizable form; (3) Distribution and delivery of heat to materials under treatment; (4) Maintenance of chemical characteristics of furnace-atmosphere; (5) Recovery of heat from waste gases and cooling load by recuperation, regeneration or preheating. For treating small parts the best form of furnace would be one having a hearth area approximately 3 ft. long by 2 ft. wide by 1 ft. to crown of arch. This type of furnace will give maximum annealing capacity. If pressings only are treated a continuous furnace of the bright annealing type is suitable. For non-ferrous works using extruding presses for making rods, sections and tubes, a twin chamber inclined hearth continuous furnace is recommended. For normalizing steel stampings a producer gas fired furnace of the continuous pusher type was found suitable. Chief advantages of pulverized fuel firing are: (1) Speed of heating; (2) High temperature quickly obtainable; (3) Economy in fuel consumption. The advantages claimed for electric resistance furnaces are: (1) Uniformity of treatment; (2) Automatic control; (3) Clean furnace atmosphere and superior finish of work. Describes also tube annealing and sheet mill furnaces. VSP(23)

REFRACTORIES & FURNACE MATERIALS (24)

Investigations on Permeability of Refractories to Gases. (Untersuchungen über die Gasdurchlässigkeit fuerfester Steine.) A. KANZ. *Mitteilungen Forschungs-Institut Vereinigte Stahlwerke Aktiengesellschaft Dortmund*, Vol. 2, No. 1 (1930), pages 1–22, 7 references.

The investigations on permeability of gas through 21 clay-, 11 silica-, 25 magnesia-, and 29 other different refractories and also 4 heat insulation materials indicate that; the permeability of gas through certain refractories varies as shown:

Material	permeability number $\left(\frac{m^3.cm.}{m^2.hr.mm.water\ pressure}\right)$
Clay brick	0.010–1.714
Silica brick	0.057–0.475
Magnesia brick	0.099–0.953
Chromite brick	0.528–5.093
Bauxite brick	0.003–0.793
Corundum brick	0.060–1.183
Sillimanite	0.037–0.100
Zirconia	0.412–4.054
Carborundum	0.010–2.691
Insulator	0.215–1.940

This shows that for chromite brick the values are higher than for the others. The permeability of gas in the refractories is for pressure up to 300 mm. water pressure proportional to the pressure. GTM(24)

Tests with Special Refractory Bricks for the Arches of Electric Furnaces. (a) Comparison Tests with Silica Bricks, Corundum Bricks and Silicon Carbide Bricks. (Ueber Versuche mit feuerfesten Sondersteinen an Elektro-ofengewölben. (a) Vergleichende Versuche mit Silika-, Korund- und Siliziumkarbidsteinen.) O. KUKLA. *Stahl und Eisen*, Vol. 50, June 5, 1930, pages 800–803. **(b) Tests on the Application of Sillimanite for Arch Material. ((b) Untersuchungen über die Verwendung von Sillimanit als Gewölbebaustoff.)** F. SOMMER. June 5, 1930, pages 804–806.

Report No. 185 of the Steel Mill Committee of the Verein deutscher Eisenhüttenleute. Includes discussion. Silicon carbide bricks stood up satisfactorily in reducing atmospheres but do not meet the requirements for the arch of furnaces which are charged cold. Silica bricks up to the present time still give the best results whereas corundum bricks fail by disintegration. The experiments with sillimanite bricks ($Al_2O_3.SiO_2$) were discontinued since no essential improvement over silica was found and sillimanite has 4 times the price. GN(24)

GASES IN METALS (25)

Condition Necessary for the Blistering of Metal During Processing. ANSON HAYES. (American Rolling Mill Co.). *Transactions American Society for Steel Treating*, Vol. 17, April 1930, pages 527–537.

Paper presented before the Eleventh Annual Convention of the American Society for Steel Treating, Sept. 1929. See *Metals & Alloys*, Jan. 1930, page 345. WLC(25)

Gas Removal and Grain Refinement of Aluminium Alloys. W. ROSENHAIN, J. D. GROGAN & T. H. SCHOFIELD. (National Physical Laboratory.) *Institute of Metals, Advance Copy* No. 531 (1930), 14 pages.

An aluminum alloy containing 12% silicon was treated with different amounts of the following chlorides: (1) carbon tetrachloride, (2) silicon tetrachloride, (3) titanium tetrachloride, (4) tin tetrachloride, (4) aluminum chloride, (6) ferric chloride, (7) tetrachlor-ethane. These compounds are all either liquid or solid at room temperature and liberate chlorine at the temperature of molten aluminum. The liquids were introduced by means of a tube and an inverted crucible and the solids were simply stirred in. Samples were cast into sand molds of various sizes. The top of an ingot cast into a 3″ × 3″ cylindrical mold gave some indication of the amount of gas liberated on solidification. This ingot was sectioned for visual examination and its density determined. All of the addition agents were found effective in removing gas. The titanium tetrachloride appeared to be the most effective. The untreated alloys appeared modified, but treatment with all reagents with the exception of titanium tetrachloride appeared to decrease modification. This reagent also decreased the grain size. Unalloyed aluminum was treated with the result that titanium tetrachloride and no other chloride decreased the grain size. The addition of a titanium-aluminum alloy also decreased grain size. The addition of titanium tetrachloride to a "Y" alloy increased its density, and its mechanical properties in the heat treated condition. Severe rolling of "Y" alloys proved that the titanium tetrachloride treatment improved the rolling properties. JLG(25)

INSPECTION (26)

Ammonia-Treated Gage Steel. A. J. WORMWOOD. (Independent Pneumatic Tool Company.) *American Machinist*, Vol. 72, Mar. 13, 1930, page 452.

A plug gage made from machinery steel and carburized with previously used material gaged an average of 90 holes per gage. Gages from the same steel but carburized with new material averaged 320 holes per gage. Gages from steel conforming to S.A.E. 5195 specifications averaged 340 holes per gage. Gages from oil hardened steel quenched at 1500° F. and drawn to 300° F. averaged 640 holes per gage. Gages from ammonia-treated steel, known as nitralloy show best results gaging an average of 1044 holes per gage before showing appreciable wear. RHP(26)

Identification of Aircraft Tubing by Rockwell Test. HORACE KNERR. *National Advisory Committee for Aeronautics, Technical Note* No. 342, June 1930, 8 pages.

A machine for making Rockwell tests on aircraft tubing in full lengths is described. Test is used to separate straight carbon steel from chrome-molybdenum steel. (26)

EFFECTS OF ELEMENTS ON METALS & ALLOYS (27)

Effects of Alloys on Rolled and Cast Steels. R. C. GOOD. *Iron & Steel of Canada*, Vol. 13, June 1930, pages 121–122, 141, 143.

Effect of chromium, nickel, manganese and silicon. Paper read before Montreal Section of American Society for Steel Treating. (27)

The Influence of Titanium on Transformation Points of Steel. (Influence du titane sur les points de transformation de l'acier.) ANDRE MICHEL & PIERRE BENEZAT. *Revue de Metallurgie*, Vol. 27, June 1930, pages 326–333; *Chimie et Industrie*, Vol. 23 (1930) pages 237–242.

A study made with Chevenard dilatometer and Saladin-Le Chatelier recalescence point apparatus showed that for 0.10–0.17% C steels, 0.5 and 0.8% Ti raise Ac_2 to 780° and bring Ac_3, respectively, to 980 and 1080°. Added to 13% Cr low carbon steel it acts more pronouncedly raising the transformation point to 890° with 0.11% Ti, to 900° with 0.14% Ti and pushing it beyond 1140° by 0.60% Ti. Quenching from under 1300° develops in Cr steels only martensite, above it delta phase appears and the amount of it increases with the rise of temperature. Microscopical evidence is clear in case of 13% Cr, 0.84% Al steels but does not show anything definite in Cr-Ti steels. 17 curves and 5 microphotographs are given. JDG(27)

Molybdenum in High Speed Steel. S. B. RITCHIE. (Captain, Ordnance Department.) *Army Ordnance*, Vol. 11, July-Aug. 1930, pages 12–19.

During the World War the scarcity of tungsten became very acute and not only were efforts made to find and develop new sources of supply of this valuable metal but also to find satisfactory substitutes. In this paper the author discusses the work carried out to determine whether satisfactory tools can be made without tungsten. The paper reports on a number of tests made with commercial high speed tools as well as molybdenum high speed steels. The tests which were made under practical working conditions indicate that: (a) molybdenum can be substituted in whole or in part for tungsten in high-speed tools, and (b) there are no difficulties of manufacture of molybdenum high-speed tools in quantity that cannot be met easily. (27)

Chromium in Cast Iron Mixtures. T. F. JENNINGS. *American Metal Market*, Vol. 37, July 1, 1930, pages 10, 12.

The ratio between nickel and chromium should be about 2:1. This paper confines attention to the effects of chromium as regards carbon, strength and ductility of gray iron, resistance to corrosion, and effects on fluidity of gray iron. The mixtures used by one foundry in casting gray iron are tabulated. Chromium increases the strength and hardness. WHB(27)

Nickel in Bearing Metals High in Lead. (Nickel in hochbleihaltigen Lagermetallen.) CH. L. ACKERMANN. *Zeitschrift für Metallkunde*, Vol. 21, Oct. 1929, pages 339–341.

The behavior of Ni in the quaternary system Ni–Sn–Sb–Pb, i. e., as the unstable $NiSb \rightleftharpoons Ni_2Sb_2$ constituent is considered and the maximum addition of Ni in bearing metals running high in lead is discussed. The influence of Ni upon the strength and particularly the improvement of the sliding qualities are considered. The behavior of Ni in the presence of small amounts of Cu is discussed and general considerations on some commercial alloys improved by Ni are given in conclusion. EF(27)

Effect of Phosphorus on the Strength of Admiralty Gun-metal. H. D. DEWS. *Foundry Trade Journal*, Vol. 43, Sept. 11, 1930, pages 181–183.

Gives results of experiment on the effect of P on mechanical properties of the solid alloy. Alloys were made from B. S. ingot Cu, Straits Sn, G. O. B. spelter soft Pb, and commercial 10% P-Cu. Effect of P is most marked between 0.04 and 0.07%. From a trace up to 0.04% P there is only a very slight increase in tensile strength and slight decrease in elongation. Above 0.04% tensile strength and elongation drop sharply. Microstructures of alloys showed no unusual features. No change in density with up to 0.06% P, and slight reduction on increase to 0.13%. Insoluble copper phosphide begins at 0.05% P. VSP(27)

Effect of Small Additions of Phosphorus on the Age-hardening of Beryllium-Copper Alloys. (Einfluss geringer Zusätze von Phosphor auf die Vergütbarkeit von Beryllium-Kupferlegierungen.) G. MASING & O. DAHL. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern*, Vol. 8, No. 1 (1929), pages 197–201.

Addition of P to Be-Cu alloys accelerates the age-hardening process and causes it to take place at lower temperatures. With 0.1% P the alloy with 1.5% Be attains its maximum hardness of 250 at 250° in 24 hrs., whereas without P more than 50 hrs. at 350° are required to produce a hardness of 142. The maximum hardness obtainable with alloys containing more than 2% Be is slightly reduced by addition of P. (27)

High-Quality Cast Iron in Modern Engineering Practice. ARTHUR B. EVEREST. *Engineering*, Vol. 130, July 11, 1930, pages 56–58.

Best quality cast-iron is produced when the combined carbon is maintained at a figure which is the maximum that can be obtained compatible with machinability. Quality and strength will be improved as the cooling rate is accelerated, until the point is reached at which the casting is unmachinable. Various methods of improving cast-iron are discussed briefly. Elements which may be added to cast-iron comprise 2 groups. In the first group are metals which promote formation of graphite from carbide, and, in the second group metals which retard the formation of graphite, keeping the iron in a hard condition. In the first group are Si, Al and Ni. Such elements as Mn, S, P, Cr and Mo are in the second group. Gives discussion of author's work on the effect of Al, Ni and Cr. It was found that Al tended to produce a finer form of graphite than Si, and the pearlite in the matrix of the iron was in a finer form. Ni was found to improve machineability of castings, tending to produce hard spots. It improves the denseness and soundness in heavy sections providing castings of uniform soundness. Cr tends to retain carbon in the combined form rather than in the graphitic form. It has tendency to lead to machining difficulties. Ni-Cr combinations are used in casting where hardness and machinability are both required. LFM(27)

LEACHING (30)

Leaching Practice and Costs at the New Cornelia Mines of the Calumet and Arizona Mining Co., Ajo, Ariz. GEORGE A. BELL. *Information Circular* 6303, July, 1930, *United States Bureau of Mines*, 29 pages. 7 references.

The ore, after crushing and charging into tanks, is leached by upward percolation with dilute solutions of sulphuric acid and ferric sulphate. The electrolyte is clarified before and after reduction of ferric iron by settling and decantation. Ferric iron is controlled by reduction with sulphur dioxide and by dissolving part of the cement copper when necessary. Copper is precipitated from pregnant solutions by electrolysis, from discard solutions by scrap iron. Details are given. Total costs for leaching are 35.7 cents/ton of ore leached. Electrolytic expense is 2.73 cents/pound and cement copper 4.05 cents. AHE(30)

Dissolution of Various Manganese Minerals. C. W. DAVIS. *Report of Investigations* 3024, *United States Bureau of Mines*, 1930, 11 pages. 32 references.

Manganese was dissolved rapidly from pyrolusite, psilomelane, wad and braunite by agitation with 2% SO_2 solution at 25° C. The action on other manganese minerals was much slower. An oxidizing roast at 650 to 900° quickly changed rhodochrosite, manganite and hausmanite so that their rates of solution were markedly increased. Over 90% of the manganese was dissolved in 3 hours and 100% in less than 24 hours from 6 to 10 mesh material of all the above except roasted hausmanite. Dissolution of hausmanite is slower during the first 12 hours, and complete reaction requires 24 hours. Unroasted manganite (28–100 mesh) requires 4 days for dissolution and unroasted rhodochrosite (28–100 mesh) 6 days. Grinding to minus 200 mesh and the use of hot solutions (40°) increased their rates of solution to approximately those for 6 to 10 mesh, less-refractory manganese minerals. No simple treatment was found to dissolve the manganese from rhodonite effectively. AHE(30)

REDUCTION METALLURGY (31)

Influence of CO and CO_2 on the Rate of Reduction of Magnetic Sand by Means of Solid Carbon. KEIZO IWASE, MASAMI KOBAYASHI & SINROKU MITSUKURI. *Kinzoku no Kenkyu*, Vol. 7, July 1930, pages 317–328.

The reduction of magnetic sand by sugar carbon in the current of CO gas was strong at 900–950° C; but it was weak in the current of CO_2 gas. The reduction at other temperatures was also investigated. KT(31)

The Value of Iron Ore or Additions to the Blast Furnace as a Function of Iron Yield. (Valeur d'un minerai de fer ou d'une addition au haut fourneau en fonction de son rendement en fonte.) J. VALLET. *Revue de Metallurgie*, Vol. 27, May 1930, pages 248–255.

Methods found in the literature do not permit the determination of the yield of ore. A method of calculation is proposed which is both simple and gives the desired information. JDG(31)

Producing Artificial Manganese Ores. T. L. JOSEPH, E. P. BARRETT & C. E. WOOD. *Iron & Coal Trades Review*, Vol. 120, April 25, 1930, pages 686–687.

Describes the work of the Bureau of Mines and Minnesota School of Mines, on the methods for recovering manganese content of manganiferous iron ores in form suitable for the production of ferromanganese. See *Metals & Alloys*, Vol. 1, Aug. 1930, page 697. RHP(31)

Equipment for Ore Dressing and Steel Plants. (Einrichtungen und Anlagen auf dem Gebiete des Aufbereitungs- und Hüttenwesens.) P. BODENSTEIN. *Krupp'sche Monatshefte*, Vol. 11, June 1930, pages 135–141.

The article gives a complete survey of equipment for ore dressing and steel plants with special reference to the "Wälz" process developed by the Gruson Works for extracting low grade ores. GN(31)

Smelting of Copper Oxide Ores in Reverberatory. (Notes sur la fusion pour mattes au reverberes de minerais oxydes de cuivre.) SAINT MAURICE. *Revue de Metallurgie*, Vol. 27, Apr. 1930, pages 214–222.

Some oxidized ores of copper do not have enough S to form workable matte after smelting in a reverberatory furnace. Addition of pyrites proved to be too expensive. It was replaced by a mixture of raw gypsum with 19% charcoal and 1% crude oil. It was used in connection with sulphide, oxide, silicate and double oxide ores always producing satisfactory mattes. Experiments were made on the plant scale, and the method adopted as standard. Thorough mixing and fine grinding are necessary. A flow sheet and necessary calculations are given. JDG(31)

The Wälz Process. B. H. STROM. *Engineering & Mining Journal*, Vol. 130, July 24, 1930, pages 56–60.

The Wälz process introduces the rotary kiln into metallurgical use for the recovery of volatile metals, such as lead, zinc, cadmium, tin, bismuth, arsenic and antimony. At present it is chiefly used in recovery of lead and zinc. The process is well adapted for the treatment of low-grade materials that cannot be concentrated profitably, and for products containing impurities prohibiting wet methods of treatment. The process opens up the possibility of recovering metal from residues, old slag dumps, tailings and middlings, and other by-products. Thirty-one furnaces are at present in operation in the U. S. A. The operation of the process is described and several illustrations shown. WHB(31)

The Reduction of Iron Oxides by Carbon. (Die Reduktion der Eisenoxyde durch Kohlenstoff.) H. H. MEYER. *Mitteilungen Kaiser Wilhelm Institut für Eisenforschung*, Vol. 12 (1930) Report 142, pages 1–6.

The reduction of iron oxides by carbon proceeds differently from the reduction by CO or hydrogen. Contrary to former investigations it was found that the reduction of iron oxides by carbon starts at rather low temperatures. The reduction of pure iron oxide, minette ore and magnetite by charcoal, sugar coal and coke was studied. The reduction of iron oxide with charcoal starts at 390° C. but ceases again as soon as the oxide is reduced to Fe_3O_4. Between 690 and 840° C. Fe_3O_4 is reduced to FeO, above 840° the product of reduction is metallic iron. The temperatures of beginning reaction are shifted to higher temperatures for other types of coal, but in any case the reaction proceeds in steps. From the different course of reaction the author concludes that the reaction does not take place in the gas phase but that it is a reduction between solid carbon and the oxides. GN(31)

Change of Properties of Hematite Pig Iron. (Aenderung der Eigenschaften des in erster Schmelzung vergossenen Hämatitroheisens.) E. PIWOWARSKY. *Stahl und Eisen*, Vol. 50, July 3, 1930, pages 966–968.

The changes of hematite iron as to temperature, chemical composition, structure and physical properties were investigated on its way from the blast furnace to the acid mixer to the casting. An improvement of all physical properties was observed for all intermediate steps. GN(31)

Stock Distribution and Gas-Solid Contact in the Blast Furnace. C. C. FURNAS & T. L. JOSEPH. *Technical Paper* 476, *United States Bureau of Mines*, 1930, 73 pages. 20 references.

Uneven stock distribution in a blast furnace causes uneven flow of gases and inefficient reduction. Size segregation is due to (*a*) greater ore-coke ratio at center than at wall caused by the greater angle of repose of the ore and (*b*) the large particles of ore tending to roll toward the center. The average size of particles at the center may be decreased by decreasing the time of depositing materials on the bed. This may be done by (1) keeping stock line close to bed, (*b*) increasing bell angle, (*c*) increasing speed and distance of bell drop and (*d*) increasing bell clearance. The average size of particle at the center is increased by (a) reversed filling-coke on the big bell first, (b) mixing-alternating skips of ore and coke, (c) decreasing size of ore change and (d) decreasing bell clearance. Unit charging has little effect. Material finer than 14 mesh is potential flue dust. Washing out minus 65 mesh ore and sintering would be profitable. The cost would be about 50 cents/ton of metal. Savings would be effected through decreased fuel consumption, increased rate of driving decreased dust handling, smoother operation and more uniform product. Crushing all ore coarser than 2 inches would be profitable. AHE (31)

The Reduction of Cuprous Oxide by Carbon Monoxide. CHAS. G. MAIER. *Report of Investigations* 2926, 1929, United States Bureau of Mines, 7 pages. 12 references.

The presence of less than 0.1 mm. CO pressure in an atmosphere of otherwise pure CO_2 will not reducingly toward cuprous oxide at all temperatures where both the copper and oxide are solid (below 1064° C.) Below 900° decreasing quantities of CO suffice to reduce the cuprous oxide. At temperatures near and above the melting point of copper, a partial pressure of 7.6 mm. of CO in otherwise pure CO_2 would reduce the dissolved cuprous oxide content to 0.008%. These concentrations define the limits which must obtain technically in the bright annealing of copper when CO is the reducer and furthermore suggest the possibility of the use of a CO_2 atmosphere containing small amounts of CO from the deoxidation of copper, both in the solid and liquid state. AHE(31)

Investigation on the Course of Reduction of Iron Ore. (Untersuchung über den Verlauf der Eisenerz-Reduktion.) H. H. MEYER. *Stahl und Eisen*, Vol. 50, July 3, 1930, pages 969–970.

Investigations on the reduction of iron ore by B. Stålhane and T. Malmberg in *Jernkontorets Annaler*, January 1930, Vol. 114, pages 1–26 are reviewed. A dense Kunna ore and a porous Tuolluvaara ore with uniform grain size were reduced between 850 and 1000° C. with pure CO and mixtures of CO and CO_2. The results confirm the fact that the reduction proceeds in layers from the outside to the inside. A complete reduction to metallic iron was never obtained, about 5% always remained as FeO. The reduction curves for CO at 950° and depth of reduction in relation to time are not straight lines, but show a slow retarding in the lower part of the curves which is explained by a decreased velocity of reduction of FeO. The tests with CO-CO_2 reduction show that the reduction of FeO to metallic iron is very much decreased even by low amounts of CO_2. The velocity of reaction increases with the temperature to decrease only at 900 to 910° C, increasing again at higher temperatures. The transformation α to γ-iron which changes the velocity of diffusion is given as reason for this retardation. Mathematical formulae are derived from the results, the calculated values for the depth of reduction in relation to time check satisfactorily with the actual test results for longer times of reduction. GN(31)

NON-METALLIC COATINGS FOR METALS (32)

Porcelain Coated Iron Conquers New Fields. L. J. LEWERY. *The Pure Iron Era, Fourth Issue*, 1929, pages 10–11, 14.

Enameled iron is put to ingenious new uses. Discusses factors controlling adherence of enamel. Gives a résumé of a study made on this subject by G. C. Clawson. MLM(32)

An Outline of the Application of Enamels to Cast Iron. J. H. D. BRADSHAW. (Bradley & Foster, Ltd.). *Foundry Trade Journal*, Vol. 42, Mar. 13, 1930, pages 193–194.

Enameling process comprises 3 distinct stages: (1) Preparation of castings. (2) Preparation of enamel. (3) Application of enamel to castings. Filling sand and blow-holes in casting is best done by using just enough clay and fluxing material to bind the whole together at firing temperature. Describes preparation of enamel and types used. Cast iron is enameled by either the "dry" or dusting process, or by the "wet" or swill process. VSP(32)

Book Reviews

Die-Casting Practice. By Marc Stern. McGraw-Hill Book Co., Inc., New York, 1930. Cloth, 5½ × 8 inches, 270 pages, 128 figs. Price, $2.50.

Die casting is a relatively new industrial process and the literature, up to the present time, has consisted entirely of articles in the technical and trade periodicals and of the catalogs and bulletins of individual concerns in various branches of the die casting field. These have dealt usually with isolated phases of the subject.

The author's book is the first attempt to bring together reasonably complete information on all of the important phases of die casting. The contents include a brief history of the various casting methods which eventually led to present-day pressure die castings; a description and discussion of various types of die casting machines; a chapter on die design; one on die steels; and a chapter on the design of parts to best adapt them to production by die casting. Other chapters discuss the dimensional accuracy and the physical properties obtainable with various alloys; the metallurgy of the alloys used in die casting and also methods of alloying and of controlling composition. The cleaning and other mechanical finishing operations, and finally, the electroplating of die castings are described.

It is obvious that all of these subjects cannot be treated in exhaustive detail in a book of this length. The author states in his preface, however, that "This book is intended******especially for those interested in the use of die cast parts. The application of die castings, the principles of design, the limitations and possibilities of the many alloys in use and the finishes applicable for such alloys are some of the factors of vital importance in the intelligent utilization of a comparatively new process." The reviewer feels that this purpose is admirably accomplished as the subject matter is clearly presented and is sufficiently detailed to give the user or prospective user of die castings an intelligent comprehension of the things he needs to know.

The experienced die caster will probably find the book of less actual value since it is not to be expected that a book describing any commercial process will divulge much more than is known to the well-informed technologists in that particular industry.

Those wishing practical information about die casting and die castings should find this book extremely helpful.—W. M. Peirce.

Arc Welding. Published by the Lincoln Electric Company, Cleveland, 1926. Cloth, 4 × 6 inches, 159 pages, 236 figs. Price, $1.50.

The introduction of electric arc-welding in many industries to replace other methods of fabrication has necessitated substantial changes in the design of parts that go to make up the completed product. While considerable space in this book is devoted to the theoretical and practical phases of arc-welding, redesigning of parts previously made by casting, riveting or forging is described and illustrated in great detail. Numerous examples of redesigning of machinery parts, structural work, tanks and a large variety of miscellaneous items are illustrated, and in many cases the savings to be effected by the use of arc-welding are given.

This book also contains considerable technical information on the strength of arc-welded joints, comparative strength of welded and riveted joints, speed and cost of welding and the cost of arc-welding compared to other methods of joining metal. Automatic welding and equipment for arc-welding are briefly touched upon.—D. L. Mathias.

Metallurgical Experiments. Iron & Steel, and Metallurgical Experiments. Non-Ferrous. By F. Johnson. Published by the author, Birmingham, 1928. Paper, 5½ × 8½ inches, 31 and 45 pages. Price, 3 sh. each.

These booklets are essentially laboratory manuals, intended to supplement lecture courses in elementary metallurgy. Emphasis is placed on chemical reaction, physical properties and also changes in physical properties of the material studied as these properties are modified through the application of metallurgical processes, such as casting, working, heat treating and finishing.

Extraction of the metals from the ores is not touched upon. To one trained in the American schools, much of the elementary chemistry and physics over emphasized in these booklets might well have been omitted, and much of the limited space thus used, devoted to more purely metallurgical experiments.

The booklets are decidedly lacking in detailed directions for conducting experiments. Elementary students of metallurgy would probably find difficulty in trying to conduct such experiments as the determination of tensile strength, torsion and the Erichsen tests without more information than given, unless the instructor were at the student's side throughout the entire test.

The incompleteness and the inclusion of so much extraneous matter do not argue well for the adoption of these manuals in the American schools.
Arthur Schroder.

Engineering Materials. Vol. 3. Theory and Testing of Materials. A. W. Judge. Isaac Pitman & Sons, New York, 1930. Cloth 6 × 8½ inches, 498 pages. Price, $6.00.

This volume is a revision and extension of the author's "Aircraft and Automobile Materials." When this work was recently revised it was separated into two volumes. The first volume, Vol. 1, Engineering Materials—Ferrous was reviewed in the Sept. 1930, issue of Metals & Alloys on page 746. The publisher announces that Vol. 2 will cover Aircraft and Automobile Materials—Non-Ferrous and Organic.

The present volume deals with the strength of materials and the various methods of making physical tests. The effect of temperature on the physica properties and the fatigue strengths of metals have been more fully dealt with in this edition. Chapters are also devoted to the discussion of testing of cast iron, impact tests and hardness tests.

In the description of testing machines the author has confined himself to the lever type machine, although at the present time a very considerable amount of testing is carried out on non-lever type machines. The descriptions of hardness testing machines are exceptionally complete. Chapters are also devoted to testing machine accessories and to special testing machines.

While it may not be strictly within the scope of this volume, information on the testing of materials for homogeneity, and detection of cracks and flaws would have enhanced the value of the book. The book can well be recommended to every materials engineer.—R. R.

The Principles of Iron Founding. Richard Moldenke. McGraw-Hill Book Co., Inc., second edition, 1930. Cloth, 6¼ × 9¼ inches, 654 pages. Price, $6.00.

It was inevitable that a second edition of this book should be called for since it is undoubtedly the best-known American text-book on founding and one of the best available in the English language. This edition is considerably larger than its predecessor; the added matter extends to some 150 pages and is naturally mainly concentrated in four chapters in which advance in the past twelve years has been most pronounced—those on cast iron metallurgy, the properties of cast iron, foundry raw materials and melting processes. The standard specifications quoted at the end are also considerably increased, although it is regrettable from the point of view of the book's British circulation that only American specifications should be included. The new British specification (B. E. S. A. 321) is referred to in several places throughout the book and the inclusion of its testing clauses and figures would have been thoroughly justified.

The new matter dealing with foundry raw materials and melting processes is admirable and calls for little comment. In view of the ferment of new ideas, developments presented in connection with the metallurgy of cast iron are of most immediate interest. In several places the expert will be struck by the apparent lack of logic in arrangement; thus the treatment of the important question of growth under the general property of fusibility, and of briquetting under the general question of specific gravity may be noted. We are glad to see that the depreciation of the value of metallography in the first edition has now been modified, for properties depend on structure, which is not wholly settled by composition. Structure is thus of vital importance to the founder.

Many students will agree with the observation about manganese diminishing chill without agreeing with the explanation offered on page 140. Recent research has indicated that the graphitizing effect of manganese in low manganese irons is due to combination with sulphur—another very potent chilling agent. This, of course, only happens with manganese below about 0.5%, and ferro-manganese added to a ladle containing more than this amount in the first place increases rather than decreases the chill. A recent explanation has been offered of inverse chilling, referred to on page 142, which so far agrees with observations made. It has been found that the fine graphite structures obtained when superheating metal, with the subsequent production of nucleus-free iron, requires more silicon to keep it gray than the ordinary pearlite normal graphite structure. Irons containing patches of nucleus-free metal are, therefore, likely to go white in a mass of gray iron, if the silicon present should be insufficient. Inverse chill can readily be produced in the way indicated by the author, and the results can be explained in terms of the nucleus theory.

While the author is evidently familiar with recent advances in connection with superheating it is regrettable that he has not included a fuller account of the results obtained and the suggestions offered to account for them. Superheating is not wholly beneficial in the foundry, as many practical men have recently found to their regret, and in England a good deal of caution is exercised by experts in recommending the use of superheated cast iron. Many practical points referred to by the author arising out of the general question of superheating will be disputed by those conversant with modern practice, but broadly speaking, the conclusion is correct that common irons repay superheating better than those of high quality.

The final chapter dealing with the testing of cast iron is very brief considering the importance of this question and the attention which has recently been paid to it. The continuous relationship between strength and section has been established for most of the mechanical properties which interest the engineer, and, furthermore, the relationship between strength and composition for a given set of melting conditions has also been made clear. In view of the large amount of work done in America on the fatigue strength of cast iron, it is surprising that more attention is not given to this. The author appears to deprecate the use of the beam formula for working out the transverse rupture stress, usually called the modulus of rupture, on transverse bars. Thus on page 196 it is said that the modulus of rupture is not a constant figure for the same iron, and that, therefore, foundrymen will prefer to use the actual breaking load. Obviously the modulus of rupture will vary if, and only if, the transverse breaking load varies on bars of the same iron and consequently in this respect neither figure is more or less reliable than the other. The advantage of using the rupture stress figure is that it eliminates variations in the transverse breaking load due to slight variations in the size of the test bar which may deceive the founder if not taken into account. The conversion method of doing this is liable to error. Rupture modulus provides also a direct basis of comparison between transverse and other tests, of very great value. Much work has recently been done on the relation between these tests which might have found a place in the book.

Many metallurgists will think that a book of this importance dealing with the metallurgy of cast iron might profitably omit recommended mixtures for a particular class of service, on the ground that they must inevitably be so general in character as to be misleading to the practical man without being particularly useful to the metallurgist. A proper study of the principles embodied in the book should equip the reader to formulate his own mixtures for particular types of castings.

These points, however, are of comparatively minor character and will not seriously detract from the value of a book which will be recognized by all interested in the subject. We hope that the author will shortly be able to add the companion volume, promised in the first edition, on the practice of iron founding.—J. G. Pearce.

Structural Aluminum-Handbook. Aluminum Company of America, Pittsburgh, 1930. Fabricoid, 5½ × 8¼ inches, 120 pages. Price, $1.00.

This is an engineering reference book similar in purpose to the well-known Carnegie Pocket Companion except that it serves the aluminum instead of the steel business. The book indicates the range of sizes which the company is capable of producing.

Part I briefly considers the manufacture of aluminum alloys, the mechanical properties of aluminum alloys, the design of aluminum alloy structures, the structural use of various alloys, the construction practice for aluminum alloys and finishing aluminum surfaces for protection or decoration.

Part II covers the elements of sections: Angles, I-Beams, Channels, Car Channels, H-Beams, Tees and Zees. This part also contains technical data on miscellaneous structural products and conversion tables and other useful data.

The book has some historical interest in that it marks the advent of aluminum and its alloys in the so-called strength structures.—R. R.

Kurzgefasste Eisenhüttenkunde. By Bernhard Osann. Max Jaencke, Leipzig, 1929. Cloth, 6 × 8¼ inches, 184 pages, 137 figs. Price, 11.40 RM.

The spiritual father of hundreds of German metallurgists who has done so much to help keep the standard of German metallurgists at a high level, has written another book, a pocket review, so to speak, of ferrous metallurgy.

The book, he says in the subtitle, is supposed to be "a hand- and reference. book for mining and mechanical engineers, chemists and other employees of steel plants and foundries, and for employees with an education as lawyers, economists and salesmen and for student-laborers." Briefly said, it is a sketch book for all those associated with the iron industry besides the metallurgist himself. Quite an undertaking, to teach to the "heathen" the secrets of our daily failure and success. Such a book really must be written by a man who has learned to listen to the secrets of nature and who has become a master in many a field of metallurgy. A man with such a profound knowledge as Osann has also learned to write in a clear and common language about "his" iron.

In five main chapters the author deals with: A. Introduction to ferrous metallurgy (Grouping of non-historical development of iron manufacturing, economics and statistics, fuels, iron and manganese ores, preparation of iron ores, furnaces, refractories). B. Production of pig iron. C. Production of steel. D. Shaping of steel. E. Structure of steel.

Though the book offers a well balanced treatise of steel making, experts on special fields, no doubt, will find in some cases "weak cross-sections." So the master Osann will excuse the reviewer, when he, as a research man, looks into the chapters on steel structures, and makes some comments.

It is really dangerous, for instance, to describe the non-carbon system in a manner as it is done on page 170. We should never forget that the iron–carbon system is an equilibrium diagram strictly following Gibbs' phase rule. And we, therefore, should not write into an equilibrium field martensitic structure, or use as a collective for martensite, troostite, sorbite and so on, austenitic structure. The "faithful" know what it means but how about the "heathen" who is to be converted? Or to make a comment on table No. 1, "Technically used carbon bearing iron" the author sticks to the old yardstick of tabulation, not taking into account that the modern metallurgist knows only steel besides strictly pure iron.

The book taken as a whole, however, is so reliable and so refreshing in style that every layman who deals with iron in his daily work will profit by reading it.—G. Neuendorff.

Einführung in Die Metallographie. By Prof. Dr. Ing. Paul Goerens. Wilhelm Knapp, Halle (Saale), 5th edition, 1926. Paper, 6½ × 9½ inches, 372 pages, 447 figs. Price, 16.50 RM.

The fifth edition differs but slightly from its predecessors, the theoretical part being condensed, and the practical part being expanded. Theoretical discussion covers 145 pages, practical part 130 pages and the metallography of iron and steel 95 pages.

The treatment throughout is clear and is well illustrated by drawings and photomicrographs. The phase rule is made the basis of the development of the types of alloys and their equilibria, transformations, etc.

The non-ferrous discussion is based on the brasses and bronzes, while simpler systems might have been selected. On the other hand, 19 binary alloys of iron with other metals have been described.

The practical part covers pyrometers, thermal analysis, furnaces, microscopes, polishing and etching methods in an adequate manner.

The references are generally to German publications, and the illustrations of equipment are from continental makers.

Rather surprising is the fact that X-ray metallography has not been included.

While there does not appear to be much that is novel in this introduction to metallography, it is well written and well illustrated. The American student may study this publication as a means of increasing his knowledge of the fundamentals of metallography and as a means of improving his German.—O. E. Harder.

Die Handformerei in der Eisengiesserei. By E. Bauer. Wilhelm Knapp, Halle (Saale), Germany, 1930. Cloth, 6¼ × 9¼ inches, 94 pages. Price 8.40 RM. Part 10 of the series on iron, steel and non-ferrous foundry practice, edited by Hubert Hermanns.

To deal with hand molding in a brief book of 90 pages is quite an undertaking, for molding is more an art than a science. No doubt the author was successful in this undertaking to a large extent in consequence of a thorough practical experience which helped him to write the book in a clear manner. The conditions in American foundries are in many respects different from those in Germany, so that the American foundryman may not be especially interested in the book. The subject, however, is not one of minor interest for the American foundryman who also tackles the problem of hand molding and education of skilled labor for this profession.

After dealing with patterns, molding sands and its preparation, tools for molding and additional equipment, the book covers the various molding methods, as open sand work, molding with patterns in flasks, loam molding, molding of intricate shapes with several cores, molding with gear wheel molding machines. In all cases Bauer has given certain practical examples, accompanied by clear illustrations.

A comprehensive presentation of the wide subject of hand molding cannot be expected in this book. Therefore, it is doubtful whether the book will be of value in every place. The experienced man cannot expect to learn more than he knows already.

The brief presentation is evidently the result of the publisher's wish not to exceed the scope of these series on foundry practice. Taking this into consideration the author has really done his best to fulfill his task.

G. Neuendorff.

Grundlagen des Verzinkens. Feuerverzinken; galvanisches Verzinken, Sherardisieren, Spritzverzinken. By H. Bablik. Julius Springer, Berlin, 1930. Paper, 6¼ × 9¼ inches, 255 pages. Price, 28 RM.

The book largely covers hot galvanizing, which on a quantitative basis represents the most important process. In the preparation for galvanizing, pickling is very thoroughly discussed. Among the subdivisions of hot galvanizing appear: the formation of the zinc coatings, their crystallization, the bending strength of the zinc coating, the operation of the dipping process, etc. Several special methods for sheet galvanizing, wire galvanizing and tube galvanizing are discussed.

The theoretical basis for electrolytic galvanizing and its operation is briefly considered. Two short chapters are devoted to sherardizing and spray galvanizing. Testing, grading and a complete bibliography end the book.—R. R.

Laminoirs a Fers Marchands. By E. Richarme. Dunod, Paris, 1929. Cloth, 171 pages, 8¼ × 10¾ inches. Price 76.50 Fr.

The author operated three merchant mills in Russia for some time, many years ago, and then, as it appears from the text, traveled through Germany and France before the War, visiting many mills. During the War years and post War year of 1919, he apparently stayed in the United States and visited almost all merchant mills. The book is a collection of notes, showing plan view, arrangement of stands, size and capacity of steam engines and driving motors, sizes rolled, output per shift and per month and much auxiliary equipment of the mills such as shears, roller tables, hot beds, straightening presses and so on.

To the experienced rolling mill man, it is quite evident that the book originated from a series of notes which were taken by the author for his own use. Throughout the book comparisons with the three Russian mills are made. There is endless repetition which could have been avoided by tabulation.

The book should be of great interest to those who wish to study the history of the older types of American merchant mills, and who wish to become acquainted with their drawbacks and shortcomings, because the author is quite keen in finding out what is wrong with each mill. It is apparent from the book that the author has not visited any American mills after 1919. Most of the mills which he visited from 1916 to 1919 were already of an older type; the enormous progress in merchant mills in the last decade is not recorded in Mr. Richarme's book.

The study of this book can be recommended to all those who wish to obtain an historical background, for a study of the reasons which have led to the great development in merchant mills in the last ten years.

The following table of contents will give an idea of the matter described in the book; blooms and billets used for the manufacture of merchant bars; drafts and reductions used in merchant mills; classification of ordinary types of merchant mills; description of such mills; classification of semi-continuous merchant mills; shapes rolled by such mills; the use of semi-continuous mills for the rolling of shapes; semi-continuous merchant mills with 8 looping stands, with 6 looping stands, with 5 looping stands, with 4 looping stands; semi-continuous mills with 4 or 6 finishing stands for straight or looped bars; cross country merchant mills; multiple trains for merchant bars; bloom and billet storage; reheating furnaces; fuel consumption in furnaces; number of motors used for each merchant mill; capacity of motors installed on merchant mills; killowatt hour consumption on merchant mills; hot shears, hot beds, (this part of the book is worth reading); roller straighteners; cold shears and cold saws; merchant bar storage; capacity of merchant mills; yield of merchant mills; capacity of American merchant mills; conclusion.—W. Trinks.

La Fabrication de la Fonte Malléable. By Camille Busquet. Dunod, Paris, 1929. Paper, 6½ × 10 inches, 150 pages, 44 figs. Price, 32 Fr.

A treatise on the production of malleable castings. The author, himself connected with the Government Railways, as chief engineer-of-tests, is particularly qualified to discuss the properties and requirements of this class of castings, and about 50 pages of the 150 comprising the book are devoted to this part of the subject.

The usual division of the subject is to be found in this book. First, the chemistry of iron, classification of iron products, fuels and refractories. Then melting processes—amongst which may be noted the practically obsolete crucible process, the chapter on which should be of high interest to the metallurgist who is historically inclined. Then follows a description of the production of French "malleable," or the usual "white-heart" product; that of the "black-heart" variety as made in the cupola following. The introduction of the air furnace for making malleable castings in France seems to have been slow, as it is called the American malleable process, and the matter is handled rather gingerly. The theories of graphitization follow and then the last division, previously mentioned as covering the properties and testing of the material at issue.

The book is a good, practical treatise on the making of malleable castings, as practised in France to-day.—Richard Moldenke.

Anleitung zum Formen und Giessen. E. Uhlenhuth. A. Hartleben, Leipzig, 1928. Paper, 5¼ × 7½ inches, 196 pages. Price, 4 RM.

This is a new edition of the 49th volume of Hartleben's Chemico-technica Library, and ranks equally in value with many of the other volumes. While very explicit and thorough in the information given, its condensed form required familiarity with and considerable experience in the subject at issue by the reader. The particular portion of the book valuable to the foundryman is that on special forms of molds and the materials and methods used in the production of art castings.

The balance of the book, relating to ordinary foundry materials, molding methods and the manner of melting ferrous and non-ferrous metals and alloys are summaries taken from larger treatises, and will need more extended reading by the student to be of direct practical use.—Richard Moldenke.

Einführung in die Metallographie. By E. Vollhardt. Bonness & Hachfeld, Potsdam, 1930. Paper, 6 × 9 inches, 52 pages. Price, 2 RM.

Part of a "self-instruction" series of the Karnack-Hachfeld System. Part 2 contains Lessons 4 and 5. The arrangement of the material is about as follows: First, a lecture, followed by a summary of the lecture material, and this in turn is followed by a group of well-chosen questions and answers. In some cases there is in addition a section devoted to a review assignment and one devoted to a special problem. The work is of quite elementary character and adapted to independent study.

Lesson 4 covers the iron-carbon alloys, going into the structures, constitutional diagram, and special discussion of steels of different carbon content. This lesson also covers the subject of heat treatment, microstructures, etc. It should be mentioned that structures such as osmondite and hardenite are given places in the micro-structures of heat-treated steel, while they are not given much consideration in American practice at the present time.

Lesson 5 deals with the constitutional diagram, hardening and improvement of steel, with some work on cast steel, the overheating of steel and correlated discussion of copper-tin and copper-zinc alloys.

The text is apparently quite well adapted to use by German students who are attempting to get a knowledge of metallography by an independent study or by a study in a correspondence course. It might be used by American students to good advantage to get an elementary knowledge of metallography and at the same time improve their reading knowledge of German.

The number of questions, problems, etc., seem to be a valuable feature of the publication.—O. E. Harder.

Patent Department

Through an arrangement with Mr. W. M. Corse, Metallurgical Engineer, Washington, D. C., who operates an Engineering Information Service, we are able to publish every month a list of important patents from the United States, Canada, England, Germany, France, Switzerland, Denmark, Holland, Sweden, Norway and Italy. Photostatic copies of patents and translations will be supplied at reasonable rates. Patent searches made at minimum rates. Estimates cheerfully given. Readers who wish information about this service may secure it by writing to the Patent Department, METALS & ALLOYS, *810 Eighteenth Street, Washington, D. C.*

United States Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Metal and process of manufacture. (Copper alloy.) J. G. Donaldson and H. L. Coles, assignors to Guardian Metals. No. 1,775,159. Dec. 21, 1926.

Furnace lining. G. D. Evans, assignor to American Smelting and Refining Co. No. 1,775,161. Mar. 14, 1928.

Soldering solution. V. Habif. No. 1,775,197. June 9, 1930.

Control means for molding machines. W. J. Fiegel, assignor to Bohn Aluminum & Brass Corp. No. 1,775,239. Sept. 17, 1928.

Oven of the direct-flame continuous-tunnel type. J. Williamson. No. 1,775,302 Nov. 7, 1927; in Great Britain Dec. 22, 1926.

Welding apparatus. B. Halle, assignor of one-half to F. Stovall. No. 1,775,311. June 30, 1928.

Manufacture of irons and steels. H. A. De Fries, assignor to Ludlum Steel Co. No. 1,775,339. Apr. 27, 1928.

Induction furnace. F. Linnhoff, assignor to Ajax Electrothermic Corp. No. 1,775,351. Dec. 7, 1928.

Uniting of iron with other metals and elements. W. H. Smith, assignor to General Reduction Corp. No. 1,775,358. Sept. 23, 1929.

Open-hearth furnace. T. T. McEntee. No. 1,775,367. Dec. 13, 1921.

Furnace-wall structure. F. J. Tone, assignor to The Carborundum Co. No. 1,775,414. Jan. 21, 1926.

Electric-arc-furnace electrode holder. O. L. Mills, assignor to Mills Alloys, Inc. No. 1,775,437. June 17, 1929.

Ingot mold. E. L. Ramsey and H. Sullivan. No. 1,775,473. Apr. 26, 1926.

Welding device. R. L. Le Boeuf, assignor to A. J. Brickner and H. W. Kropf. No. 1,775,532. Sept. 16, 1929.

Combustibly-destructible mold core. A. C. Waters. No. 1,775,576. May 29, 1929.

Production of beryllium. H. S. Cooper, assignor to Beryllium Corp. No. 1,775,589. Aug. 8, 1928.

Electrothermic zinc furnace. E. C. Gaskill. No. 1,775,591. Sept. 17, 1928.

Method of and apparatus for co-spatial fuel and electric heating. G. T. Southgate. No. 1,775,606. Dec. 30, 1927.

Alloy steel. J. A. Succop, assignor to Heppenstall Co. No. 1,775,615. June 12, 1930.

Dipping means for quenching articles. A. S. Phelps, assignor to Pratt & Letchworth Co. No. 1,775,254. Dec. 28, 1928.

Metal cement. (*Si-Mn and Fe-Si.*) W. R. Chapin. No. 1,775,670. Apr. 29, 1929.

Metallic mold and process of forming the same. W. H. Smith. No. 1,775,701. Apr. 22, 1927.

Process for the reduction of ores of reducible oxides. T. F. Baily. No. 1,775,-713. Jan. 3, 1924.

Process of treating ores. T. P. Holt. No. 1,775,767. July 11, 1928.

Art of soldering the links of wire chains or chain mesh. J. Wenz *et al.*, assignors to E. G. Bek. No. 1,775,839. Feb. 14, 1927.

Method of casting steel and other metals. A. G. E. Hultgren. No. 1,775,859. July 28, 1928; in Sweden Aug. 8, 1927.

Aluminum-beryllium alloy. R. S. Archer and W. L. Fink, assignors to Aluminium Company of America. No. 1,774,542. Dec. 19, 1928.

Metal blank or billet. C. A. Parsons and E. G. Brownlow, Brownlow assignor to Parsons. No. 1,774,563. (Original filed Jan. 21, 1928; in Great Britain Feb. 7, 1927.) May 2, 1929.

Method of bonding refractories. S. J. Lubowsky, assignor to Metal & Thermit Corp. No. 1,774,607. Dec. 5, 1925.

Cushioning device for presses. F. J. Rode. No. 1,774,614. Mar. 6, 1929.

Web-forming attachment for foundry patterns and the like. C. H. Reeder. No. 1,774,668. May 31, 1929.

Electrode. M. O. Sem, assignor to Det Norske A/S. for Elektrokemisk Industri of Norway. No. 1,774,674. May 14, 1928; in Norway May 21, 1927.

Process of metal casting. D. E. Willard. No. 1,774,687. Nov. 7, 1927.

Refining of lead bullion. G. K. Williams. No. 1,774,688. Mar. 28, 1929; in Australia Apr. 11, 1928.

Material for contact points and the like. (Ag-Cu-Co). J. A. Williams. No. 1,774,689. Sept. 25, 1925.

Babbitting machine. W. J. Fiegel and W. S. Enderich, assignors to Bohn Aluminum and Brass Corp. No. 1,774,794. Dec. 19, 1927.

Crucible for aluminothermic reactions. H. Schultz. No. 1,774,816. July 24, 1929; in Germany Aug. 31, 1928.

Method of working metal. H. H. Dow and J. E. Hoy, assignors to The Dow Chemical Co. No. 1,774,824. July 30, 1926.

Process for the deoxidation of molten metals or alloys. G. Masing, assignor to Metal & Thermit Corp. No. 1,774,837. Mar. 1, 1928; in Germany Apr. 11, 1927.

Hard alloy for tools and the process for their production. K. Schröter, assignor to General Electric Co. No. 1,774,849. Oct. 30, 1923; in Germany Mar. 21, 1923.

Resistor and support therefor. D. L. Summey, assignor to Scovill Manufacturing Co. No. 1,774,852. June 5, 1926.

Metal-cutting tool and alloy for making the same. W. A. Wissler, assignor to Haynes Stellite Co. No. 1,774,862. May 19, 1926. (Cr-W-Ni-B-C.)

Blowpipe apparatus. I. Allison, assignor to The Oxweld Railroad Service Co. No. 1,774,865. Sept. 23, 1925.

Method of producing mercury. W. Glaeser, assignor to Glaeser Research Corp. No. 1,774,883. Nov. 14, 1924.

Process for chromium plating. R. J. Piersol. No. 1,774,901. Nov. 6, 1928.

Electrode for the electric arc. E. K. Dewey, assignor to General Electric Co. Nos. 1,774,964 and 1,774,965. July 6, 1925.

Method of heat treating nitrided articles. R. Sergeson, assignor to Republic Steel Corp. No. 1,774,999. Sept. 20, 1929.

Hard metallic composition. R. L. Adams, assignor to General Electric Co. No. 1,775,014. July 31, 1929.

Casting mold. F. Liers. No. 1,776,591. Nov. 15, 1926; in Germany Nov. 25, 1925.

Casting mold for aluminothermic rail welding. H. Schultz. No. 1,776,601. July 2, 1929; in Germany July 4, 1928.

Tin-coated chromium-iron alloy and method of making the same. L. Schulte, assignor to Allegheny Steel Co. No. 1,776,603. May 25, 1926.

Heating of the rolls of metal-rolling mills. K. Younghusband. No. 1,776,607. Dec. 1, 1928; in Great Britain Dec. 19, 1927.

Joint and method of making the same. D. M. Boothman and J. A. Cullerton, assignors to Aluminum Company of America. No. 1,776,615. Dec. 12, 1928.

Hot-rolling-mill layout. A. R. McArthur, assignor to American Sheet and Tin Plate Co. No. 1,776,635. Oct. 19, 1928.

Molding sand. L. L. Mathieu, assignor to S. A. des Hauts-Fourneaux et Fonderies de Pont-à-Mousson. No. 1,776,686. Dec. 29, 1928; in France Apr. 27, 1928.

Welding machine. C. L. Ipsen *et al.*, assignors to General Electric Co. No. 1,776,731. Feb. 19, 1929.

Protective device for use in hot-metal ladles. F. L. Arensberg, assignor to Vesuvius Crucible Co. No. 1,776,773. July 1, 1929.

Refining of copper. H. H. Alexander. No. 1,776,826. July 5, 1928.

Process of galvanizing sheet metal. B. P. Finkbone, assignor to The American Rolling Mill Co. No. 1,776,852. Nov. 30, 1925.

Making flanged tubes and the like. H. S. Holmes, assignor to Metropolitan Engineering Co. No. 1,776,855. Jan. 23, 1929.

Pickling composition. H. J. John, assignor to N. A. Emery. No. 1,776,858 Apr. 2, 1927.

Intermediate table for double shears. L. G. Leichner, assignor to The American Rolling Mill Co. No. 1,776,861. Sept. 4, 1928.

Gagger. G. L. Southard. No. 1,776,867. Apr. 8, 1929.

Iron carbonyl compositions and their manufacture. A. Mittasch and M. Müller-Cunradi, assignors to I. G. Farbenindustrie A.-G. No. 1,776,920. Apr. 22, 1925; in Germany Dec. 5, 1924.

Alloy. (*Cu-Al-Ni-Be-Sn.*) A. G. Krans, assignor of one-half to J. S. Kirstein. No. 1,776,948. July 26, 1929.

Manufacture of steel. E. H. Graf, assignor to The Lusifer Products Co. No. 1,777,081. Nov. 23, 1928, original filed Nov. 7, 1925.

Method of protecting metal bodies from corrosive agencies. P. F. Schade, assignor to Chemieprodukte G. m. b. H. No. 1,777,107. Nov. 11, 1927; in Germany July 27, 1927.

Method of electrodeposition of metals and alloys. L. L. Linick. No. 1,777,121. Nov. 3, 1927.

Recuperative soaking pit. G. R. McDermott, assignor to The Chapman-Stein Furnace Co. No. 1,777,125. Apr. 4, 1928.

Hydraulic cushion for sheet-metal presses. F. J. Rode, assignor to Marquette Tool & Mfg. Co. No. 1,777,130. May 11, 1928.

Magnetic sheet catcher. J. G. Fitzgerald and L. M. Ripple, assignors to Republic Steel Corp. No. 1,777,139. June 14, 1928.

Method of improving copper or copper alloys and hardener for use therein. W. Machin and W. B. O. Goudielock, assignors to P-M-G Metal Trust, Ltd. No. 1,777,174. July 10, 1929; in Great Britain Apr. 4, 1929.

Manufacture of copper alloys. (Cu-Si-Fe.) Same patentees and assignee. No. 1,777,192. Mar. 5, 1930; in Great Britain Dec. 12, 1929.

Soldering apparatus. O. Sieper, assignor to Moto Meter Gauge & Equipment Corp. No. 1,777,233. June 8, 1928.

Austrian Patents

Subject of Invention, Patentee, Patent No. and Date of Beginning of Term of Patent.

Direct process for working up iron ores. Staalsyndicat Dr. Ledeboer, II. No. 119,015. Apr. 15, 1930.

Pasty covering medium for use in the local case-hardening of iron and steel. F. Krusek. No. 119,023. Apr. 15, 1930.

Means for preventing gas losses in bright-annealing furnaces filled with a protective gas. A. G. Brown, Boveri & Cie. No. 119,303. Nov. 15, 1928.

Permanent mold. The Automotive Engineering Co., Ltd. No. 119,057. Apr. 15, 1930.

Die casting machine having a plurality of molds. S. Junghans. No. 119,052. Apr. 15, 1930.

Process for reducing simple or complex ores with hydrocarbons alone or together with hydrogen. Soc. Italiana per le Industrie Minerarie e Chimiche. No. 119,017. Apr. 15, 1930.

Process for producing potassium from potassium fluoride. I. G. Farben industrie A.-G. No. 119,021. Apr. 15, 1930.

Lead-base bearing metal of light metals which contains only alkali metals. O. Grünbaum. No. 118,864. (Addition to No. 109,161.) July 15, 1928.

Improvable copper casting alloy having a high copper content and a smaller content of silicon, nickel, iron and zinc. Metallbank und Metallurgische Ges. A.-G. No. 119,014. Apr. 15, 1930.

Process for refining magnesium and its high percentage alloys. I. G. Farbenindustrie A.-G. No. 119,266. Mar. 15, 1930.

Process for the electrolytic production of magnesium. A. C. Jessup. No. 119,-010. Apr. 15, 1930.

Electrode holder for electric furnaces. Det Norske A/S for Elektrokemisk Industri. No. 119,011. Apr. 15, 1930.

Method of working electrothermic processes. Gräflich Schaffgotsch'sche Werke G. m. b. H. No. 119,016. Apr. 15, 1930.

Process for producing aluminum and aluminum alloys. T. R. Haglund. No. 119,307. Apr. 15, 1929.

Process for the electrodeposition of gold. H. Paweck and R. Weiner. No. 119,-022. Apr. 15, 1930.

Means for the electrolytic production of iron in the form of sheet, strips, sections, etc. Osterreichische-Alpine Montanges. No. 119,031. Apr. 15, 1930.

Disk-rolling mill. Demag A.-G. No. 119,006. Apr. 15, 1930.

British Patents

NOTE: Names of communicators, if any, are given in parentheses after the name of applicant. When the date applied for differs from the date on which the application was lodged at the British Patent Office, the former date is followed by*.

Subject of Invention, Patentee, Patent No. and Filing Date.

Electrical induction furnaces. N. R. Davis, G. A. Wood and Associated Electrical Industries, Ltd. No. 333,582. May 15, 1929.

Reduction of iron ores. Trent Process Corp. No. 313,597. June 16, 1928.*

Recovery of copper from dilute ammoniacal solutions thereof. I. G. Farbenindustrie Akt.-Ges. No. 313,045. June 5, 1928.*

Manufacture of metal tubing. J. H. Beaumont (Titeflex Metal Hose Co.). No. 333,674. June 6, 1929.

Art of shaping metal sheets. E. B. Carns. No. 333,675. June 7, 1929.

Barrels made of aluminum or its alloys. F. Eichleiter. No. 333,678. Nov. 13, 1928.*

Method of manufacturing rolled-iron rail-chairs. J. Chatwin (Vereinigte Stahlwerke A.-G.). No. 333,688. June 24, 1929.

Process of and apparatus for producing metal sheets by electrolytic means. E. Kelsen. No. 314,434. June 27, 1928.*

Welding iron or steel alloys containing copper. F. Krupp A.-G. No. 316,614. Aug. 1, 1928.*

Alloys. W. P. Digby. No. 333,774. May 30, 1929.*

Machines for rolling metal tubes. Witkowitzer Bergbau- und Eisenhütten Gewerkschaft. No. 333,800. Nov. 20, 1928.*

Producing a titanium or ferro-titanium regulus. W. Mathesius and H. Mathesius. No. 333,816. Nov. 1, 1928.*

Method and apparatus for freeing and extracting castings from sand molds. L. A. Camerota and W. Wood. No. 333,860. Jan. 24, 1930.

Covering for metal sheets, etc. Hatmaker. No. 283,692. (Amended specification published.)

Method and means for corrugating sheets of metal and other bendable materials. Bertrams, Ltd., and J. Allan. No. 333,340. June 14, 1929.

Molding-sand projecting-machines. W. Seidemann. No. 318,990. Sept. 15, 1928.

Mandrel for tube-rolling mills. P. Multhaupt. No. 333,368. Nov. 26, 1928.

Protective devices or alarms for metal-melting furnaces. British Thomson-Houston Co., Ltd. No. 315,841. July 19, 1928.

Machines for straightening and rolling metal plates and sheets. K. F. Ungerer. No. 333,382. Aug. 1, 1929.

Constructional steel. F. Krupp Akt.-Ges. No. 319,319. Sept. 20, 1928.

Guide for straightening rolls. G. A. Wise. No. 333,431. Sept. 26, 1929.

Method and machine for extruding metal. Hirsch, Kupfer und Messing-Werke Akt.-Ges. No. 333,437. Oct. 13, 1928.

Production of bronze. G. Bartges. No. 333,442. Oct. 2, 1929.

Electric induction furnace. Hirsch, Kupfer-und Messing-Werke Akt.-Ges. No. 333,455. Oct. 15, 1928.

Electric furnaces. British Thomson-Houston Co. No. 333,457. Oct. 23, 1928.

Ore-carrier for circular Dwight-Lloyd type blast-roasting apparatus. Berzelius Metallhütten Ges. No. 333,461. Mar. 27, 1929.

Electrolytic deposition of gold and silver. A. Mozer. No. 333,462. Dec. 11, 1928.

Welding of copper. W. Andrews and Imperial Chemical Industries, Ltd. No. 333,466. Nov. 2, 1929.

Production of iron and steel castings. J. E. Fletcher. No. 333,494. Jan. 10, 1930.

Forming hollow bodies, such as tubes, by skew rolling. F. Kocks. No. 308,783. Mar. 31, 1928.*

Foundry molding-machines. E. Leyondre. No. 318,131. Aug. 28, 1928.*

Arc welding. Elin A. G. für Elektrische Industrie. No. 312,358. May 25, 1928.*

Method of dissolving and removing metallic fouling from the surface of iron and steel objects. G. Halbe. No. 333,963. May 31, 1929.

Electrodes or welding-rods for use in the process of electrically welding or depositing metals. J. E. Pollack (R. D. Thompson and G. C. Mills.) No. 333,985. June 11, 1929.

Furnaces for the heat treatment of metallic or other bodies. Wellman Smith Owen Engineering Corporation, Ltd., and E. W. Plumley. No. 334,006. July 2, 1929.

Tube-expanding apparatus. Demag A.-G. No. 334,047. Mar. 23, 1929.*

Producing iron carbonyl. Vereinigte Stahlwerke A.-G. No. 319,356. Sept. 22, 1928.*

Electrical soldering-devices. Electrische Löt-und-Schweissges. No. 334,092. Mar. 19, 1929.*

Production of a good conducting electrical connection between a metal compound layer and a coating of a ductile metal applied thereon. Siemens-Schuckertwerke A.-G. No. 334,140. Dec. 5, 1928.*

Method of and apparatus for the manufacture of metal tubes by extrusion presses. Hydraulik Ges., and O. Schlenstedt. No. 334,159. Feb. 11, 1929.*

Automatic moving of forgings while being forged. Vereinigte Stahlwerke A.-G. No. 334,161. Mar. 4, 1929.*

Blow-pipe cutting-apparatus. M. Claude. No. 334,162. Mar. 5, 1929.*

Method of heat-treating boring or drilling tubes and rods. Mannesmannröhren-Werke. No. 308,346. Mar. 22, 1928.*

Case-hardening by nitrogenization. Electro Metallurgical Co. No. 314,423. June 27, 1928.*

Blow-pipe-burner devices for cutting holes in metal. H. Greggersen. No. 313,042. Apr. 24, 1929.

Apparatus for cleaning articles of metal or other material. Chemisches Werk Zurich A. G. No. 313,599. June 15, 1928.*

Melting metal or heating molten metal in an electrical furnace, and a furnace for carrying out the said process. K. G. Wennerstrom. No. 334,201. May 28, 1929.

Lead alloy for electric cable sheath and other purposes. Standard Telephones & Cables, Ltd. No. 314,522. June 29, 1928.*

Making carbon electrodes and the like. Roessler & Hasslacher Chemical Co. No. 312,940. June 1, 1928.*

Presses for extruding metals. F. Krupp Grusonwerk A.-G. No. 316,259. July 26, 1928.*

Extrusion of metal pipes and the like. P. Dunsheath. No. 334,315. July 1, 1929.

Manufacture of cast-iron grinding balls. F. Krupp Grusonwerk A.-G. No. 319,350. Sept. 22, 1928.*

Foundry molding-machines. E. O. Beardsley and W. F. Piper. No. 334,416. Oct. 19, 1929.

Processes of pickling metals, and materials used therefor. Barrett Co. No. 334,418. Oct. 31, 1928.*

Aluminum alloy. H. C. Hall and T. F. Bradbury. No. 334,430. Oct. 24, 1929.

Casting light metals especially aluminum and aluminum alloys. Vereinigte Aluminium-Werke A.-G. No. 334,435. Oct. 29, 1928.*

Method and apparatus for extracting castings from sand molds. L. A. Camerota and W. Wood. No. 334,484. Jan. 24, 1930.

Production of metals from ores. E. A. A. Grönwall and H. J. H. Nathorst. No. 334,500. Apr. 26, 1929.

Metallization of electric non-conducting and/or inert base materials. J. G. A. Rhodin and British Metallizing Co., Ltd. No. 334,510. May 29, 1929.

Tape or wire for loading conductors. Standard Telephone & Cables, Ltd., and W. H. Dearden. No. 334,547. May 31, 1929.

Method and apparatus for changing the form and improving the texture of hollow metal articles. United States Cast Iron Pipe & Foundry Co. No. 334,634. Dec. 29, 1928.*

Aluminum-base alloys. Aluminium, Ltd. No. 334,656. Dec. 22, 1928.*

Casting of metals or alloys. Metal Castings, Ltd., and A. H. Nicholson. No. 334,714. Sept. 12, 1929.

Cleaning of castings by water under pressure. J. J. V. Armstrong. (Badischen Maschinenfabrik & Eisengiesserei.) No. 334,722. Sept. 21, 1929.

Rolling mills. F. Chamier. No. 334,734. Sept. 28, 1929.

Electrolytic recovery of tin in the form of compact plates of any desired thickness from alkaline lyes containing alkali stannate. No. 334,738. (Addition to No. 286,673.) Siemens & Halske A. G. Mar. 28, 1929.*

Process for reducing the quantity of sulphurous acid gas set free from copper glance on its roasting. M. Miyake. No. 334,761. Oct. 18, 1929.

Rolling of channel sections with wide flanges. J. Meiser. No. 334,767. Oct. 25, 1929.

Aluminum alloys. K. Schmidt Ges. No. 334,777. Aug. 15, 1929.*

Cutting apparatus employing cutting burners. Oberbau Ges. and W. Hillmann. No. 334,815. Dec. 20, 1929.

Forming of molds for pipe-like castings. E. Moussiaux. No. 334,611. June 7, 1929.*

Canadian Patents

Subject of Invention, Patentee, Patent No., and Filing Date.

Portable stack lifter. R. T. Romine. No. 303,553. Oct. 15, 1926.

Car loading and unloading method. R. T. Romine. No. 303,554. Nov. 18, 1926.

Method and apparatus for handling metal. R. T. Romine. No. 303,555. May 23, 1927.

Method and apparatus for handling materials. R. T. Romine. No. 303,556. June 28, 1927.

Method and apparatus for handling bar and strip material. R. T. Romine. No. 303,557. June 28, 1927.

Electrolytic cell. The American Smelting & Refining Company, assignee of F. F. Poland. No. 303,580. July 8, 1929.

Malleable iron. The Canadian General Electric Company, Ltd., assignee of I. R. Valentine. No. 303,592. Sept. 28, 1928.

Non-magnetic ferrous alloy. The Canadian Westinghouse Co., Ltd., assignee of H. Scott. No. 303,601. Apr. 3, 1929.

Welding electrode. The Canadian Westinghouse Co., Ltd., assignee of I. G. Ritter. No. 303,602. July 27, 1929.

Process of pyrometallurgically refining and casting copper. The Coalescence Products Co., Inc., assignee of H. H. Stout. No. 303,605. May 23, 1927.

Induction furnace. Consortium für Electrochemische Industrie, assignee of M. Mugdam and R. Meingast. No. 303,608. Apr. 6, 1925.

Process of preparing homogeneous alloys of lead. I. G. Farbenindustrie, assignee of K. Muller *et al.* No. 303,619. Oct. 24, 1928.

Apparatus for the direct production of iron from its ores. The Gathmys Research Corp., assignee of S. L. Madorsky. No. 303,026. Feb. 1, 1926.

Serpentine refractory composition. The Harbison-Walker Refractories Co., assignee of R. H. Youngman and G. K. Schlotterer. No. 303,630. July 22, 1929.

Process of making steel insensible to the action of hot gases or vapors. Fried. Krupp A.-G., assignee of B. Strauss. No. 303,641. Nov. 24, 1926.

Article of metallic oxides. (*Iron-tungsten alloy base.*) The Sirian Lamp Co., assignee of J. A. Heany. No. 303,669. June 12, 1924.

Cadmium plating. The Udylite Process Co., assignee of J. O. Wagner and A. S. Ascher. No. 303,679. Nov. 10, 1928.

Welded joint for radiators. T. E. Murray, assignee of G. H. Phelps. No 303,694. Sept. 19, 1928.

Rolling mill plant. W. C. Oberg and A. W. Soderberg. No. 303,700. Jan. 2, 1929.

Ore reducing method. A. E. Bourcoud. No. 303,719. July 9, 1926.

Apparatus for reducing ores and metallic compounds. R. McKnight. No. 303,767. Oct. 21, 1929.

Resistant alloy of iron. (*Iron-chromium.*) I. G. Farbenindustrie A.-G., assignee of C. Müller, *et al.* No. 303,830. Apr. 29, 1929.

Iron-silicon alloy. I. G. Farbenindustrie A.-G., assignee of C. Müller, *et al.* No. 303,831. Apr. 29, 1929.

Manufacture of articles for chemical plants. (*Low-carbon chrome-nickel steel.*) Thos. Firth & Sons, Ltd., assignee of W. H. Hatfield. No. 303,833. Mar. 11, 1929.

Method of making coated iron and steel articles. The Parker Rust Proof Co., assignee of E. M. Jones. No. 303,862. Sept. 3, 1929.

Method of making high-acid phosphates of iron. The Parker Rust Proof Co., assignee of M. Green and E. M. Jones. No. 303,863. Dec. 28, 1929.

Method of making welding electrodes. J. A. Roebling's Sons Co., assignee of H. J. Horn. No. 303,867. July 9, 1929.

Roller spun metal manufacture. The Spun Steel Corp., assignee of W. R. Harrison. No. 303,878. Feb. 11, 1929.

Spun metal article. The Spun Steel Corp., assignee of R. G. Nelson. No. 303,879. Feb. 11, 1929.

Magnet material and magnet core. (*Nickel-iron.*) The Western Electric Co., Inc., assignee of J. W. Andrews and R. Gillis. No. 303,895. Oct. 18, 1928.

Hot top for ingot molds. M. G. Dumas. No. 303,926. May 12, 1928.

Ingot mold. E. Gathmann. No. 303,931. July 20, 1929.

Hot rolling mill layout. The American Sheet & Tin Plate Co., assignee of A. R. McArthur. No. 303,993. Mar. 13, 1929.

Method of surfacing rolls. The American Sheet & Tin Plate Co., assignee of E. E. Moore *et al.* No. 303,994. May 8, 1929.

Metallic article. I. G. Farbenindustrie A.-G., assignee of L. Schlecht and W. Schubardt. No. 304,017. Mar. 18, 1929.

Recovery of platinum metals. Johnson Matthey & Co., Ltd., assignee of A. R. Powell and E. C. Deering. No. 304,033. May 4, 1929.
Extruding die for bolts and screws. The Neely Nut and Bolt Co., assignee of A. S. White. No. 304,047. Aug. 10, 1929.
Smelting of ferro-alloys in the blast furnace. S. G. Allen, assignee of F. W. Davis. No. 304,083. May 25, 1926.
Reduction of metals out of their ores. E. A. A. Grönwall and H. J. H. Nothorst. No. 304,092. May 6, 1929.
Melting furnace. W. Buess. No. 304,109. Aug. 22, 1927.
Apparatus for electrolytically manufacturing metal sheets and tubes. E. Kelsen. No. 304,134. July 19, 1928.
Electrolysis of ferrous chloride. S. I. Levy. No. 304,138. Mar. 1, 1928.
Apparatus for hardening steel. S. I. Salzman. No. 304,158. Aug. 21, 1929.
Electrode. Det Norske A/S for Elektrokemisk Industri, assignee of M. O. Sem. No. 304,193. Jan. 13, 1928.
Casting mold. The Dominion Brake Shoe Co., Ltd., assignee of J. S. Thompson. No. 304,194. July 22, 1929.
Iron alloy. (Iron from iron carbonyl.) I. G. Farbenindustrie A.-G., assignee of W. Gaus and L. Schlecht. No. 304,213. Mar. 27, 1929.
Production of foam for acid metal-cleaning baths. The American Chemical Paint Co., assignee of J. H. Gravell. No. 304,227. Mar. 10, 1928.
High silicon and high manganese steel. The American Steel Foundries, assignee of W. C. Hamilton. No. 304,229. May 27, 1929.
Extraction of copper-nickel matte. The Harshaw Chemical Co., assignee of W. Harshaw and G. L. Homer. No. 304,243. May 31, 1929.
Manufacture of cylindrical stepped open shells. Fried. Krupp A.-G., assignee of P. Wolf. No. 304,247. Oct. 18, 1929.
Method of heat treating (cast) iron. The Meehanite Metal Corp., assignee of A. F. Meehan. No. 304,254. July 31, 1929.
Process of treating sulphide ores. R. H. Channing, Jr. No. 304,291. Mar. 25, 1927.
Process for making steel. The Granular Iron Co., assignee of J. K. Smith. No. 304,303. June 2, 1927.
Apparatus for reducing oxides of metals. The Granular Iron Co., assignee of J. W. Hornsey. No. 304,304. July 25, 1927.
Reduction of metals from their ores. Same patentee and assignee. No. 304,305. July 25, 1927.

Danish Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Machine for centrifugally casting long and narrow objects. P. Ferrier. No. 42,705. Mar. 15, 1929.
Lead cable and process for making it. Siemens-Schuckertwerke A.-G. No. 42,717. July 9, 1929.
Process and apparatus for the internal heating of furnaces or reduction chambers for reducing ores, oxides and the like. H. E. Coley. No. 42,745. June 4, 1929.

French Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process for the thermal decomposition of iron carbonyl. Vereinigte Stahlwerke A.-G. No. 691,557. Mar. 7, 1930.
Improvements to lead alloys, especially to those for making cable sheaths. M. Thielers. No. 691,603. Mar. 8, 1930.
Process for refining cementation copper which is equally applicable to other kinds of subdivided copper. E. Crivelli. No. 691,632. Mar. 10, 1930.
Method and machine for changing the shape and the texture of hollow metal bodies. United States Cast Iron Pipe & Foundry Co. Addition No. 37,198. (First addition to No. 678,028 filed July 8, 1929.) July 8, 1929.
Improvements to electric welding machines. J. E. J. Languepin. No. 691,498. May 28, 1929.
Patterns for bath-tubs or similar vessels. P. Dupont. No. 691,518. May 30, 1929.
Hydraulic device for clamping two sheets which are to be joined by fusion welding. Siemens-Schuckertwerke A.-G. No. 691,577. Mar. 8, 1930.
New method for testing the strength of sheet metal and apparatus for applying the same. C. Jovignot. No. 691,554. Mar. 7, 1930.
Method of improving the operation of electric melting furnaces. Demag Elektrostahl G.m.b.H. No. 691,543. Mar. 7, 1930.
Improvements to coreless electric induction furnaces. Associated Electrical Industries, Ltd. No. 691,598. Mar. 8, 1930.
Electric furnace for melting metals. E. F. Russ. No. 691,638. Mar. 10, 1930.
Alloy having high elasticity. N. V. Philips' Gloeilampenfabrieken. No. 691,823. Mar. 12, 1930.
Device for hardening the sides of the threads of screws and endless screws F. Klopp. No. 691,685. Mar. 11, 1930.
Improvements in drive of flying shears. Morgan Construction Co. No. 691,774. Feb. 28, 1930.
Process for making a seam joint between metal sheets. F. Oberdorfer G. m. b. H. No. 691,840. Mar. 13, 1930.
Improvements to sanding chambers of metal-cleaning machines. C. A. Dreisbach. No. 691,907. Mar. 14, 1930.
Improvements to electric welding machines. L. Bourdelles. Addition to No. 37,273. (First addition to No. 686,882 filed Mar. 12, 1929.) Apr. 10, 1929.
Vertical hydraulic press, particularly for lead-sheathed cables. Fried. Krupp Grusonwerke A.-G. No. 692,211. Mar. 18, 1930.
Designing rolls for a pilger mill. L. Klein. No. 692,219. Mar. 18, 1930.
New tool steel and process for making the same. F. P. Thuaud and P. M. Croisard. No. 692,124. June 7, 1929.
Furnace for the direct production of steel from ore and pulverized coal. L. A. M. J. de Thy. No. 692,129. June 7, 1929.
Improvements in the production of magnesium alloys. The Dow Chemical Co. No. 692,240. Mar. 16, 1930.
Method of blowing air for the production of soft iron or steel. Comptoir Technique Albert Knaff & Leon Mayer. No. 692,314. Mar. 19, 1930.
Casting process and metal molds particularly adapted to pressure casting. Fonderie de Precision. No. 692,008. Mar. 15, 1930.
Electric apparatus for welding the joints of metallic tubing, by preheating the tubes by means of electrodes and making the actual weld by the use of autogenous torch. H. Mayweg. No. 692,014. Mar. 15, 1930.
Apparatus for cutting sheet metal with a torch. Cie. Générale de Construction. No. 692,087. June 3, 1929.
Improvements to apparatus for preparing molding sand. J. E. Germelle. No. 692,089. June 3, 1929.
Device for treating metal bars. Morgan Construction Co. No. 692,274 Mar. 19, 1930.
Improvement in the electroforming of metals. Imperial Chemical Industries, Ltd. No. 692,044. Mar. 17, 1930.
Fusible electrode for electric welding. La Soudure Electrique Autogène, S. A. No. 692,113. June 6, 1929.
Process for the formation in chromium baths of a protective layer for preventing the formation of chromium fog. R. Blasberg. No. 692,254. Mar. 19, 1930.
Muffles and heating elements for electric resistance furnaces. Etablissements Bekso. No. 692,298. Mar. 19, 1930.
Process for making carbonyl compounds of metals. I. G. Farbenindustrie A.-G. No. 691,993. Mar. 15, 1930.
Process for producing metallic carbonyls. I. G. Farbenindustrie A.-G. Addition No. 37,284. (First addition to No. 677,548 filed June 28, 1929.) July 29, 1929.

German Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process and apparatus for treating magnetizable metals and other objects in a furnace. S. A. Ugine-Infra. No. 507,069. May 25, 1929.
Process for the formation of a coherent, electrically well-conducting layer on electrically conducting crystals, for dry rectifiers for example. Hanovia Chemical & Mfg. Co. No. 506,729. Dec. 18, 1927.
Method of operating electric furnaces to obtain higher temperatures. J. J. Bronn. No. 507,074. Mar. 20, 1926.
Electric flash welding machine. Adolf Pfretzschner G. m. b. H. No. 506,668. Dec. 3, 1929.
Process for welding and soldering with radiant heat, particularly electrically produced heat. E. Schröder. No. 506,669. (Addition to No. 498,501.) Feb. 11, 1928.
Method of welding sole plates to iron ties. Siemens-Schuckertwerke A.-G. No. 507,150. Mar. 25, 1926.
Welding-wire holder. Siemens-Schuckertwerke A.-G. No. 507,116. June 12, 1927.
Muffle furnace. P. Herrmann. No. 506,824. June 24, 1927.
Tilting sintering pot. J. E. Greenawalt. No. 506,852. Dec. 15, 1928.
Device for conveying charge material or fuel into mechanical roasting furnaces with several stages. A. G. Danks Svovlsyre- & Superphosphat-Fabrik and K. Warming. No. 506,982. May 31, 1929.
Prevention of falling through in suction roasting apparatus. Bergwerksges. Georg von Giesche's Erben. No. 506,583. June 18, 1929.
Reduction furnace for the production of aluminum. Vereinigte Aluminium-Werke A.-G. No. 506,584. Dec. 18, 1928.
Device for measuring the depth of impression in the ball hardness test. Losenhausenwerk Düsseldorfer Maschinenbau A.-G. No. 506,586. Jan. 31, 1926.
Articulated coupling for roll necks meeting at an obtuse angle. H. Becker. No. 507,774. Dec. 9, 1928.
Air-cooled hot-straightening machine for sheet metal. Gebr. Irle Maschinenfabrik. No. 507,775. Nov. 22, 1929.
Press for forming strip metal by means of co-acting rolls. Electrical Research Products, Inc. No. 507,777. May 9, 1928; in the United States, June, 9, 1927.
Process for finish-drawing rough-drawn cylinders and shells. E. Linde. No. 507,778. Dec. 11, 1928.
Compressed-air sheet holder for double strokes on single-action presses. H. Spörl. No. 507,779. Apr. 13, 1929.
Process for stamping various objects out of metal sheets. F. Humphris. No. 507,780. Feb. 26, 1927.
Device for applying oil to the work in draw-presses. H. Spörl. No. 507,627. Aug. 8, 1929.
Process for making hollow rings out of sheet metal annuli. Kleineisenwerk Vossloh G. m. b. H. No. 507,628. Nov. 9, 1926.
Thread-rolling machine, Allgemeine Elektricitäts Ges. No. 507,408. Nov. 5, 1927.
Method of operating blast furnaces. F. Heyd. No. 507,321. June 6, 1928; in Czechoslovakia Sept. 12, 1927.
Refractory fettling block for blast heaters or other heat-exchange devices and process for making the same. Vereinigte Stahlwerke A.-G. No. 507,499. Jan. 27, 1928.
Process and apparatus for case-hardening iron with liquid cementation agents. C. Hummel. No. 507,206. Aug. 19, 1926.
Rotary case-hardening furnace with a worm conveyor. H. Gesslein. No. 507,423. Aug. 13, 1927.
Furnace for the continuous hardening of wire or strip. Selas A.G. No. 507,322. Feb. 15, 1928.
Electric soldering device. Elektrische Löt- und Schweiss-G. m. b. H. No. 507,826. Mar. 20, 1929.
Device for controlling the temperature of furnaces. Siemens-Schuckertwerke A.-G. No. 507,828 Nov. 15, 1927
High-frequency induction furnace. Siemens & Halske A.-G. No. 507,556. June 11, 1927.
Automatic induction furnaces. P. Viry. No. 507,442. Dec. 13, 1928; in France, Dec. 12, 1927
Machine for electrically welding disk wheels. The Dunlop Rubber Co., Ltd. No. 507,235. Sept. 25, 1924; in Great Britain Nov. 16, 1923.
Feeding and overlapping device for seam-welding machines. "Peco" Elektrische Schweissmaschinenfabrik Rudolf Bocks. No. 507,557. (Addition to No. 494,947.) Oct. 30, 1929.
Electrode feed device for electric arc welding machines. R. Sarazin. No. 507,666. June 11, 1927; in France Feb. 12, 1927.
Treatment of metals and alloys which contain at least two different metals, for the purpose of separating one or more of these metals by the use of oxidizing agents. H. Harris. No. 507,769. June 24, 1925; in the United States, Dec. 11, 1924.
Process for electroplating ceramic bodies. Porzellan Fabrik Kahla, Zeigniederlassung Freiberg. No. 507,218. May 12, 1929.
Process for locally thickening electrodeposits, particularly at places most subject to wear. Firma Otto Kaltenbach. No. 507,623. June 6, 1928.
Pipe-bending machine. Firma Arnold Klarwasser. No. 507,220. Dec. 16, 1927.
Device for soldering objects, particularly cable ends. Allgemeine Elektricitäts Ges. No. 507,378. May 26, 1929.
Device for cutting holes by burning. H. Propfe & Co.m.b.H. No. 507,379. Oct. 10, 1929.
Extraction of tin from ores or stanniferous material by reduction of the tin to metal. E. A. Ashcroft. No. 508,342. May 17, 1928; in Great Britain July 7. 1927.

High-lead copper alloy for bearings and packing. K. L. Ackermann. No. 508,154. Mar. 24, 1926.

Process for making tin-free alloys of copper, nickel and aluminum. The International Nickel Co., Inc. No. 508,198. June 4, 1926; in the United States June 16, 1925.

Nickel alloys, particularly for electric conductors. W. S. Smith, H. J. Garnett and J. A. Holden. No. 508,199. Jan. 5, 1927; in Great Britain July 10, and Sept. 24, 1926.

Process for obtaining a fine-grained recrystallization structure in objects made of aluminum or aluminum alloys. Erftwerk A.-G. No. 508,155. Apr. 8, 1924.

Process for making wax- and soap-like compositions electrically conducting. The Gramophone Co., Inc. No. 508,206. Mar. 1, 1928; in Great Britain Mar. 21, 1927.

Apparatus for copper-plating intaglio printing cylinders and similar objects. H. Pfanhauser. No. 508,157. Jan. 3, 1928.

Protective coating for food containers or the like made of metal or iron. O. Hertling. No. 507,858. Sept. 29, 1928.

Process for hot tinning or leading iron. Matuschek Metallindustrie Gustav Radtke. No. 508,043. Mar. 30, 1928.

Process and apparatus for the production of metallic coatings. American Machine and Foundry Co. No. 508,375. Apr. 1, 1926.

Process for making muffles. G. Tiegel. No. 507,859. Apr. 11, 1929.

Process for producing adherent coatings on aluminum and its alloys. A. Pacz. No. 508,207. (Addition to Patent No. 480,995.) May 13, 1928.

Machine for upsetting iron. L. Münter. No. 508,434. Mar. 9, 1929.

Electrically-driven machine for forging, straightening, stamping, cutting, etc. Berlin-Erfurter Maschinenfabrik Henry Pels & Co., A.-G. No. 508,158. Apr. 26, 1929.

Machine for bending iron bars. A. Wagenbach. No. 508,435. Sept. 25, 1927.

Process for rolling thin sheet metal in packs. Eisen- und Stahlwerk Hoesch A.-G. No. 507,960. Mar. 29, 1929.

Coiling device for strip metal. W. Bauer. No. 508,383. May 11, 1927.

Device for ejecting tubes from an extrusion press. Hydraulik G. m. b. H. No. 508,165. Sept. 16, 1926.

Extrusion press. Serck Radiators, Ltd. and O. Serck. No. 508,166. Nov. 12, 1927; in Great Britain Jan. 3, 1927.

Process for straightening sheets, strips, flat material, sections, wires of any cross-section, and the like. C. Hack. No. 507,983. May 3, 1929.

Mill for rolling twist drills by means of helically ribbed rolls. B. Reinhardt. No. 508,089. Sept. 9, 1928.

Process for heating and reducing molten ore in reverberatory furnaces. H. C. Hansen. No. 507,963. Feb. 12, 1925.

Welding method, particularly for rail joints. Ges. für wirtschaftlichen Bahnoberbau m. b. H. No. 508,172. Apr. 5, 1927.

Electric heating element. Heraeus-Vacuumschmelze A. G. and W. Rohn. No. 508,008. Oct. 30, 1928.

Electric annealing and hardening furnace. Heraeus-Vacuumschmelze A.-G. and W. Rohn. No. 508,009. Mar. 9, 1926.

Water-cooled inductor coil for induction melting furnaces. Ajax Electrothermic Corp. No. 508,332. Nov. 24, 1925; in the United States Nov. 29, 1924.

Method of protecting carbon electrodes for electric furnaces, particularly for fusion electrolysis, against burning in the air. I. G. Farbenindustrie A.-G. No. 508,190. Dec. 24, 1927.

Roasting sulphur ores and other sulphur-bearing materials. Säurefabrik Schweizerhall. No. 508,340. Feb. 22, 1928; in Switzerland Jan. 19, 1929.

Rotary furnace for roasting sulphidic ores. Zellstoffabrik Waldhof and Metallges. A.-G. No. 508,341. Mar. 24, 1927.

Process for recovering zinc from impure zinc liquors, for example from the lixivia from chloridizing roasted pyrites. Duisburger Kupferhütte. No. 508,071. Sept. 19, 1925.

Automatic device for guiding bars from skew straightening rolls to a runway. H. Cremer. No. 508,209. Feb. 15, 1929.

Machine for straightening tubing, round bars, etc., by means of skew rolls. Maschinenfabrik Sack G.m.b.H. No. 508,210. June 25, 1929.

Welding magnesium and its alloys. I. G. Farbenindustrie A.-G. No. 508,352, Apr. 27, 1929.

Soldering machine. Firma Julius Klinghammer. No. 508,212. Jan. 22, 1930.

Process for working metals and alloys by rolling, hammering, pressing, drawing or similar working methods. Siemens & Halske A.-G. No. 508,436. Jan. 14, 1928.

Pneumatic traction feed device for pilger rolling mills. Demag A.-G. No. 508,662. Jan. 3, 1926.

Traction device for pilger rolling mills. W. Feller. No. 508,646. May 9. 1928.

Device for turning iron sections, particularly for rolling mills. Demag A.-G. No. 508,663. Mar. 7, 1929.

Device for tilting ingots. J. P. Kieffer. No. 508,664. Dec. 25, 1929.

Brake for strip rolling mills. Fried .Krupp Grusonwerk A.-G. No. 508,665. Jan. 22, 1929.

Method of intermittently pulling tubing over a mandrel. The Fulton Syphon Co. No. 508,886. Dec. 20, 1927.

Pipe-drawing bench. Press- und Walzwerk A.-G. No. 509,040. (Addition to No. 447,197.) Feb. 12, 1928; in France Feb. 12, 1927.

Process for making ribbed tubing. H. Dorndorf. No. 509,041. Dec. 18, 1928.

Combined hand and motor drive for dampers for blast furnace gas or air. Duscher & Cie., A.-G. No. 508,798. Sept. 3, 1929.

Process for making steel in the converter. Eisen- u. Stahlwerk Hoesch A.-G. No. 508,966. June 1, 1924.

Coil for high-frequency furnaces. Heraeus-Vacuumschmelze A.G., and W. Rohn. No. 509,065. Aug. 9, 1927.

Coil for high-frequency furnaces. Heraeus Vacuum Schmelze A.-G., and W. Rohn. No. 509,066. (Addition to No. 509,065.) Feb. 17, 1928.

Recovery of copper and zinc from the leachings of chloridizing roasted ores. Metallges. A.-G. and Hochofenwerk Lübeck A.-G. No. 508,508. Apr. 26, 1927.

Improvement of copper-aluminum alloys. Berg-Heckman-Selve A.-G., Zeigniederlassung Carl Berg. No. 508,603. Oct. 21, 1928.

Process for forming electrolytic deposits of chromium on metals. Rawas-Maatschappij. No. 509,023. May 9, 1926.

Process for the formation of corrosion-proof protective layers on improved light metals or alloys. Vereinigte Aluminium-Werke A.-G. No. 508,554. Aug. 14, 1928.

Process for forming a rust-preventive layer on iron or steel objects. N. V. Mij. tot Exploitatie van de Parker Octrooien "Parker Rust Proof." No. 508,785. Apr. 14, 1927; in the United States May 10, 1926.

Welding agent for magnesium alloys. I. G. Farbenindustrie A.-G. No. 509,024. June 13, 1928.

Welding agent for magnesium. I. G. Farbenindustrie A.-G. No. 509,025. ((Addition to No. 509,024.) June 8, 1929.

Process for joining silver surfaces. W. C. Heraeus G. m. b. H. No. 508,528. Sept. 1, 1929.

Process for making pistons having a head of light metal and a skirt of hard metal. G. Michel. No. 508,743. Mar. 22, 1927; in France July 19, 1926.

Process for making aluminum cooking utensils. H. Kuhn. No. 508,658. Oct. 28, 1927; in Switzerland Dec. 8, 1926.

Italian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Improvements to copper alloys. G. M. Corson. No. 269,513. May 5, 1928; in Belgium Aug. 5, 1926. (Belgian Patent No. 335,861.)

Improved hot top for ingot molds. G. M. Dumas. No. 269,649. June 6, 1928.

Process for producing superheated cast iron melts. K. Emmel and Vereinigte Stahlwerke A.G. No. 269,205. Mar. 5, 1928; in Germany Mar. 15, 1927.

Process for refining chromium ore. I. G. Farbindustrie A.-G. No. 269,126; Apr. 14, 1928; in Germany Apr. 16, 1927.

Composition for soldering metals. K. Geisel. No. 268,933. May 24, 1928. in Germany Feb. 20, 1928.

Treatment of iron ore and the like. Granular Iron Co. No. 269,341. Mar. 26, 1928.

Process for extracting tin from stanniferous and plumbiferous substances in the state of oxides. Hüttenwerke Trotha A.G. and W. Witter. No. 269,509. Apr. 4, 1928; in Germany May 18, 1927.

Process for precipitating rhodium, iridium, osmium and ruthenium. N. V. Philips' Gloeilampenfabrieken. No. 268,947. May 9, 1928; in the Netherlands Oct. 20, 1927.

High-carbon acid-resistant iron alloy. Oesterreichische Schmidtstahlwerke A.-G. No. 269,384. Apr. 13, 1928; in Austria Apr. 15, 1927.

Improvements to magnetic alloys. W. S. Smith *et al.* No. 269,269. Apr. 30, 1928; in Great Britain Apr. 30, 1927.

Process for obtaining hardenable alloys of aluminum not only with magnesium silicide but also with metals which form solid solutions. S. A. pour l'Industrie de l'Aluminium. No. 269,040. May 30, 1928; in Switzerland Nov. 5, 1926. (Swiss Patent No. 124,793.)

High-resistance aluminium alloy. Same patentee. No. 269,693. May 29, 1928; in France July 21, 1922. (French Patent No. 554,248.)

Process for hardening high-speed steel. W. Stauffer. No. 269,127. May 29, 1928; in Switzerland Apr. 28, 1927.

Improvements to methods and apparatus for the electrodeposition of metals on metallic substances. J. & C. Stone, Ltd. No. 269,622. Apr. 20, 1928; in Great Britain Apr. 22, 1927 in the name of F. G. Martin and W. Ramsay.

Process for obtaining especially hard and tough metals and alloys by adding a chemical compound of nitrogen. R. Walter. No. 269,235. May 12, 1928; in Germany May 13, 1927.

Device for stretching hollow bodies. Demag A.-G. No. 269,695. May 30, 1928; in Germany May 31, 1927.

Method and device for heating crucibles. Deutsche Gold und Silber Scheideanstalt vormals Roessler. No. 268,924. Apr. 23, 1928; in Germany Sept. 23, 1927.

Process for the high speed rolling of strip and sheet iron. Eisen & Stahlwerk Hoesch A.-G. No. 269,434. May 4, 1928

Improvements to liquid-metal pumps for type-casting machines. Lanston Monotype Corp., Ltd. No. 268,977. May 22, 1928.

Improvements to devices for electrically welding (brazing) bandsaws. G. Malaguti. No. 269,149. Apr. 17, 1928.

Iron alloy. Oesterreichische Schmidstahlwerke A.-G. No. 269,391. Apr. 26, 1928; in Austria Apr. 28, 1927 in the name of L. Klüger.

Installation for the centrifugal manufacture of any kind of pipe, particularly metal pipe. Soc. d'Expansion Technique. No. 269,572. May 15, 1928; in France May 19, 1927.

Improvement to iron alloys. B. D. Saklatwalla. No. 269,300. May 19, 1928; in Great Britain June 30, 1927. (British Patent No. 288,861.)

Device for introducing a current of gas into bright-annealing furnaces. A. G. Brown, Boveri & Cie. No. 269,517. May 7, 1928; in Germany May 25, 1927.

Improvements in the construction of cupolas. L. Mugnani. No. 269,601. Mar. 21, 1928.

Electric furnace for heating metals. Siemens-Schuckertwerke A.-G. No. 269,432. May 4, 1928; in Germany June 15, 1927.

Electric resistance furnace. G. Trümpler. No. 269,346. Apr. 30, 1928; in Switzerland May 1, 1927.

Swedish Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process and machine for making horse-shoe nails. O. Mustad & Sön. No. 70,353. (Addition to No. 65,621.) May 24, 1929. Priority date May 30, 1928.

Tilting furnace, for electric reduction or melting for example. E. G. T. Gustafsson and B. I. Noren. No. 70,357. Dec. 23, 1925.

Process for making homogeneous pourable titanium or iron-titanium melts. W. Mathesius and H. Mathesius. No. 70,412. Oct. 31, 1929. Priority date Nov. 1, 1928.

Process for making a bronze alloy. J. Härden. No. 70,414. Nov. 12, 1927.

Electrolytic chromium plating process. R. Appel. No. 70,469. May 17, 1926.

Device for cutting holes by autogenous burning. H. Greggersen. No. 70,470. Apr. 3, 1929. Priority date June 5, 1928.

Rod-rolling mill. AB Svenska Kulagerfabriken. No. 70,481. Dec. 1, 1928.

Apparatus for heating the rolls of a rolling mill. John Summer & Sons, Ltd. No. 70,482. Dec. 3, 1928; priority date Dec. 19, 1927.

Process for making an electrically-conducting preparation. W. I. Einstein. No. 70,512. Dec. 11, 1928. Priority date Dec. 21, 1927.

Process for making shaped pieces for tools of difficultly workable substances such as carbides, their alloys and the like. Fried. Krupp A.-G. No. 70,514. June 10, 1929. Priority date June 15, 1928.

Furnace for sintering, roasting and burning. E. C. Loesche. No. 70,535. Aug. 24, 1928. Priority dates Sept. 20, 1927 and May 5, and July 25, 1928.

Manufacturers' Literature Reviews

In this department we shall list each month a selection of the catalogs, books, treatises and other printed matter issued by manufacturers which, in our judgment should be of interest to the readers of METALS & ALLOYS. *Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter for consideration by the editor of this department are invited to do so, and it is suggested that* METALS & ALLOYS *be placed on the regular mailing list so that advance copies of any material of interest to the metallurgical field may automatically come to this department.*—EDITOR.

1110—**Better Methods.**—The September issue of this periodical published monthly in the interest of the foundry industry contains the last instalment of an article by Prof. Enos entitled "Some Elementary Facts about Cast Iron." This article is reprinted from METALS & ALLOYS. Other articles are entitled "Long Life Molds and Their Uses" and "Installation of Patterns." Beardsley & Piper Co., 2541 N. Keeler Ave., Chicago, Ill.

1111—**Structural Aluminum.**—120-page book, bound in fabricoid. Indicates range of structural sizes company is capable of furnishing. Similar information on aluminum shapes as are contained in Carnegie Pocket Companion for steel shapes. Price $1.00. Aluminum Company of America, Oliver Bldg., Pittsburgh, Pa.

1112—**Corrosion.**—A new booklet on the Cad-A-Loy process and the zinc process discusses applications for protecting iron and steel equipment against atmospheric corrosion, as well as corrosion by certain chemical fumes. Roessler & Hasslacher Chemical Co., 10 E. Fortieth St., New York, N. Y.

1113—**Glass-Lined Equipment.**—Catalog 714 illustrates and describes a variety of glass-lined commercial equipment for pharmaceutical, rayon, sugar, petroleum and other process industries. Pfaudler Co., Rochester, N. Y.

1114—**Graphite Paint.**—Interesting literature, including a chart of color samples is available on the special protective paint made of flake graphite combined with silicon. Particularly good corrosion resistance against smoke, fumes, dust, temperature variations, etc., is claimed. Joseph Dixon Crucible Co., Paint Sales Division, Jersey City, N. J.

1115—**Material Handling.**—A new 4-page bulletin gives a reprint of an interesting article, "Cutting Handling Cost in Shipping Vegetable Potash," applying pneumatic conveying. Dust Recovering & Conveying Co., Cleveland, Ohio.

1116—**Pump Selection Charts.**—A new 32-page bound bulletin gives interesting and extensive curves, charts and other graphic data on performances of different types of centrifugal pumps. Illustrations and discussions of various centrifugal pumps are also included. Goulds Pumps, Inc., Seneca Falls, N. Y.

1117—**Sprockets and Chain Drives.**—This catalog is complete in every respect, containing not only data on Silent and Roller Chains but also engineering data of practical value to chain users in figuring chain drives. The Union Chain & Mfg. Co., Sandusky, Ohio.

1118—**Silver.**—Bulletin No. 4 is of timely interest on this subject. It gives data concerning physical and chemical properties of silver. Handy & Harman, 57 William St., New York, N. Y.

1119—**Strong Aluminum Alloys.**—Discusses the different steel aluminum alloys produced by the Aluminum Company of America, Pittsburgh, Pa.

1120—**Welding of Aluminum.**—Discusses the fusion welding of aluminum and contains tables showing the strength of welding. Aluminum Company of America, Pittsburgh, Pa. Other bulletins by the same company: "The Riveting of Aluminum" and "Machining Aluminum."

1121—**Screw Machine Products of Aluminum.**—This booklet describes the screw machine products made of aluminum and contains tables giving specifications for them. Aluminum Company of America, Pittsburgh, Pa.

1122—**Pyrometers.**—Catalog No. 15A indicating recording and controlling pyrometers for measuring temperatures to 3000° F. described and illustrated. Brown Instrument Co., 4482 Wayne Ave., Philadelphia, Pa.

1123—**Conveyor Furnaces.**—4 Types of continuous chain belt conveyor furnaces are fully described and illustrated. Electric Furnace Co., Salem, Ohio.

1124—**Magnesidon.**—This new basic refractory material is compared with other refractory bricks. American Demag Corporation, 310 S. Michigan Ave., Chicago, Ill.

1125—**Fuel Fired Furnaces.**—Describes some outstanding installations of fuel fired equipment and illustrates the range, temperature and heat treatment for which fuel furnaces can be supplied. The Electric Furnace Company, Salem, Ohio.

1126—**Nitralloy.**—This 35 page booklet issued as one of the Technical Bulletin Series of the Associated Alloy Steel Company, Cleveland, Ohio, describes nitralloy and the nitriding process.

1127—**Nirosta KA2 and KA4.**—Gives tables showing the resistance of these steel to corrosion. This is one of the Technical Bulletin Series of the Associated Alloy Steel Company, Cleveland, Ohio. Other bulletins in this series: Physical Properties of Nirosta KA2 and Fabrication of Nirosta.

1128—**Stainless Irons and Steels.**—This booklet in the Technical Bulletin Series of the Associated Alloy Steel Company, Cleveland, Ohio, describes a special non-corrosive and heat-resisting steel produced by this company.

1129—**Tool Steel.**—In this indexed and illustrated 48 page booklet there is described the tool steels manufactured by the Ludlum Steel Co., Watervliet, New York. Another bulletin by this same company: Ludlum Products.

1130—**Calite Alloys.**—A pamphlet containing a brief description of the Calite alloys giving the physical properties and uses. Calorizing Company, Wilkinsburg Station, Pittsburgh, Pa.

1131—**SCH Industrial Furnaces.**—Bulletin No. 17 shows a few of the models manufactured by the Strong, Carlisle & Hammond Company, Cleveland, Ohio.

1132—**New-Type Cutting Oils.**—A 62-page booklet describes the oil products originated by the D. A. Stuart & Company, Chicago, Ill.

1133—**Aluminum Casting Alloys.**—Describes the Alcoa standard alloys and gives miscellaneous physical data concerning them. Aluminum Company of America, Pittsburgh, Pa. Another bulletin by the same company, Alcoa Aluminum Die Castings.

1134—**Chronographs and Accessories.**—Catalog B. The Chronographs and accessories listed in this catalog are intended for recording time intervals of practically any duration, and will be found useful in every kind of Laboratory, in Astronomical Observatories, in Industrial Establishments, etc. Various types of instruments are offered for timing intervals as small as hundredths of a second and less or intervals of many hours duration. The Gaertner Scientific Corporation, 1201 Wrightwood Avenue, Chicago, Ill.

1135—**Compressor Unit.**—The Cooper Bessemer new type compressor is designed and built especially for air and gas compressing services. This catalog fully describes and illustrates this unit developed by the Bessemer Corporation, Mount Vernon, Ohio.

1136—**The Glass Lining.**—The September-October Number of this periodical contains an article on the new property of milk which may help prevent food spoilage. This article was written especially for the Glass Lining by Dr. Jones and Dr. Sims of the Rockefeller Institute for Medical Research. Pfaudler Company, 89 East Ave., Rochester, N. Y.

1137—**Electric Furnaces.**—The Electric Furnace Company of Salem, Ohio, has published a bulletin containing an article reprinted from Heat Treating and Forging, entitled: "Electric Heat in the Annealing of Metals," written by their Assistant Chief Engineer.

1138—**The Laboratory.**—In addition to several interesting short articles the latest issue of this bulletin published by the Fisher Scientific Company of Pittsburgh, Pa., contains a Hydrogen-ion Indicator Chart to facilitate the selection of a suitable indicator for laboratory and plant-control work.

1139—**Purite.**—The Mathieson Alkali Works at 250 Park Avenue, New York, have collected a number of their bulletins dealing with Purite and bound them under one cover. A list of these follows: Bulletin No. 305, "Fluxing with Purite;" No. 308, "Purite in Non-Ferrous Metallurgy;" No. 287, "Desulphurizing with Purite;" No. 285, "Refining Iron with Purite;" No. 286, "Purite in Malleable."

1140—**Tantalum.**—The October number of the Industrial Bulletin published by the Arthur D. Little, Inc., Cambridge, Mass., contains a short article on the properties of Tantalum. In the same issue is an interesting article discussing ammonia and its uses.

1141—**Special Furnaces.**—"SC gas-fired 24" wire mesh belt continuous annealing furnace is described in a 4-page folder issued by the Surface Combustion Co., 2375 Dorr Street, Toledo, Ohio.

1142—**Tool Steel.**—New patent cobalt-chromium steel "Cobalterom," is described in a leaflet distributed by the Ziv Steel & Wire Co., Chicago Ill., agents for the Darwin & Milner, Inc., of Cleveland, Ohio. Another leaflet describes "Neor," and oil-hardening non-deforming high carbon-chromium alloy steel.

1143—**Resistance Rods.**—The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., have developed new Zircon Non-Inductive Resistance Rods. Data concerning this is given in a leaflet published by the same company.

1144—**Cutters.**—A 4-page broadside illustrates and discusses cutters designed and manufactured by the Brown and Sharpe Mfg. Co., Providence, R. I.

1145—**Blast Furnaces.**—The H. A. Brassert & Company, 310 South Michigan Ave., Chicago, Ill., have issued 2 leaflets, one describing their new Checker Construction Hot Blast Stove, and the other describing their Blower Vortex Collector for dry cleaning of blast furnace gas.

1146—**Laboratory Apparatus Electrically Heated.**—Leaflets describe Trent Electric Furnaces and electrically heated melting and pouring pots, as well as laboratory apparatus. Harold E. Trent Co., 439–443 N. 12th St., Philadelphia, Pa.

1147—**Furnace Doors.**—Folder sent out by the E. J. Codd Co., of 200 S. Caroline Street, Baltimore, Md. Tells where chain furnace doors are used and how they are constructed.

1148—**Automatic Polishing Machine.**—The laboratory of the Bureau of Standards has designed an Automatic Polishing Machine which is described in a leaflet issued by the Chemical Rubber Co., Cleveland, Ohio. Another leaflet by the same company describes metallographic polishing machine manufactured by the Warner & Swasey Co.

Metals & Alloys, 3619 Forbes St., Pittsburgh, Pa.

Please have me supplied with a copy of each piece of Manufacturers' Literature the number of which I list below.

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Name..... Position.....

Firm..... City.....

Street & No..... State.....